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CLINICAL AND NEUROPSYCHOLOGICAL MEASURES AS PREDICTORS OF MALE STUTTERERS' RESPONSE TO INTENSIVE STUTTERING THERAPY

BY

LAURA ANN MANZ

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE

DEPARTMENT OF SPEECH PATHOLOGY AND AUDIOLOGY

EDMONTON, ALBERTA
SPRING, 1988

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FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled "Clinical and Neuropsychological Measures as Predictors of Male Stutterer's Response to Intensive Stuttering Therapy," submitted by Laura Ann Manz in partial fulfillment of the requirements for the degree of Master of Science.

Einar Boberg
(Supervisor)

Paul Hagler

Lorne T. Yeudall

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Date: April 14/88

DEDICATION

To my parents, whose early encouragement and sacrifice provided the basis for my academic career.

To my husband Michael, who deserves much of the credit for the completion of this thesis. His constant source of support and encouragement was a necessary condition for the completion of my graduate studies.

To the above and the remainder of my loving family, my deepest appreciation.

ABSTRACT

The first neurophysiological model of stuttering, the notion that stuttering is related in some way to cerebral dominance, originated in the 1920's with Orton and Travis. However, owing to lack of sophisticated equipment and investigative techniques, as well as competition from another theoretical model, this avenue of research was abandoned. In the last decade, with the advent of newer and more reliable means of investigating hemispheric processing there has been a resurgence of interest in a neurophysiological model for stuttering. A growing body of evidence suggests atypical hemispheric processing of speech and language in stutterers.

The present study combined assessment procedures from speech pathology and neuropsychology to ascertain which variables are the best predictors of subject response to intensive stuttering therapy.

Seventeen male stutterers served as subjects in this study. Four clinical speech and thirteen neuropsychological measures were administered to each subject prior to treatment. The four clinical speech measures were re-administered immediately following completion of the intensive three-week behavioral stuttering treatment program. All measures were visually inspected in the form of univariate graphs. As well, step-wise multiple regression analyses were utilized to determine which variable, or combination of variables, was best able to predict the post-treatment clinical results.

Results suggested a relationship between post-treatment severity and pre-treatment neuropsychological measures, and post-treatment attitudes and pretreatment severity. Regression equations were derived which accounted for 70.00% of the variance in post- treatment frequency of stuttering, 81.70% of the variance in post-treatment rate of speech, and 90.70% of the variance in post-treatment attitudes toward stuttering for the sample used in this study. Caution must be exercised in applying these predictive equations to the population. Yet, the results are sufficiently encouraging to merit further study.

The study also yielded provocative findings regarding subgroups within the stuttering population. It demonstrated that clinical and neuropsychological measures may be useful as a means for identifying subgroups of stutterers.

Recommendations were also made for further research into the prediction of treatment outcome. Recommendations included increased duration of the project to include long-term outcome measures, increased numbers of subjects, attempts to obtain more random samping, and greater homogeneity of subject population.

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CHAPTER ONE: INTRODUCTION

INTRODUCTION

The present study was concerned with exploring the possibility of using clinical and neuropsychological variables to predict subject response to intensive behavioral stuttering therapy. To date, no such prediction has been reported, but researchers in the field (Boberg & Yeudall, 1984; Daly, Kimbarrow, & Smith, 1977; Liebetrau & Daly, 1981; Smith & Daly, 1980) suggested that it might be profitable to use neuropsychological diagnostic techniques as a measure of cerebral dysfunction amongst stutterers.

Prediction of outcome to intensive stuttering therapy is important if optimal remediation is to be achieved. An accurate predictor variable may aid in caseload selection and it may increase treatment effectiveness by indicating the most appropriate therapeutic approach for individual clients. Investigators have long attempted to predict outcome of therapy on the basis of pre-treatment measures, yet a review of the literature shows a paucity of valid predictor measures within speech pathology. It may prove advantageous to look beyond the bounds of our own field of study to those of a related field.

The theoretical frame of reference for this study stemmed from the early 1920's neurophysiological model of stuttering suggested by Orton and Travis. Travis (1931) suggested that competition between the cerebral hemispheres during motor speech behavior resulted in asynchronous action potentials in the jaw muscles, resulting in disruptions in the speech of stutterers. Electromyographic (EMG) recordings from the masseter muscles of 24 adult stutterers (Travis, 1934) provided initial support for the theory. Early EMG investigations (Morley, 1935; Steer, 1937; Strother, 1935) supported Travis' findings, however, a later EMG investigation (Williams, 1955) contradicted Travis' interpretation of the results. Williams attributed the differences he found in jaw EMG recordings to excessive muscular tension and different patterns of jaw movements accompanying stuttering rather than a lack of cerebral dominance.

Owing to a lack of sophisticated equipment and investigative techniques for assessing hemispheric processing, as well as the apparent lack of support for the Orton-Travis theory found in the Williams (1955) investigation, this avenue of research was abandoned. In the last decade, with the advent of newer and more reliable means of investigating brain function, there has been a resurgence of interest in this area, with particular emphasis on hemispheric processing. Researchers made use of numerous well-established means of determining hemispheric specialization. These include: dichotic listening, tachistoscopic visual procedures, sodium amytal injection, cerebral blood flow, electrophysiological methods, dual-task paradigms, and neuropsychological test batteries.

A growing body of research suggested that there were differences in central nervous system (CNS) functioning amongst stutterers. According to Moore & Boberg (1987), there was compelling evidence to suggest that "stutterers typically did not use primarily left hemispheric strategies to process language as did normal speakers. Rather, most stutterers used primarily right hemispheric or bilateral strategies in processing language." (p. 14) The specific nature of the abnormality in hemispheric activation in stutterers was still unclear. Boberg, Yeudall, Schopflocher, and Bo-Lassen (1983) and Yeudall (1985) proposed that inadequate interhemispheric inhibition of the left hemisphere over the right hemisphere was the origin, while Webster (1985) suggested that interhemispheric interference of the left hemisphere speech mechanisms by the right hemisphere may be at the root of stuttering.

If stutterers, or a subgroup of stutterers, evidence aberrant interhemispheric relationships, it may be advantageous to utilize measures of brain functioning as predictor variables. The field of neuropsychology has at its disposal numerous indirect measures of brain functioning. From these measures, the integrity of brain functioning can be inferred.

PURPOSE

The present study was designed to explore whether clinical speeach and neuropsychological variables are useful in predicting a subject's response to intensive stuttering therapy. It attempted to ascertain which variable or combination of variables was the best predictor.

Subjects were assessed prior to treatment using four clinical and thirteen neuropsychological measures. The clinical speech measures were re-administered immediately following completion of an intensive three-week stuttering treatment program. The pre-treatment measures were then examined to determine which variable, or combination of variables, was best able to predict the post-treatment clinical results. The specific question was:

What clinical and / or neuropsychological variable or combination of variables serves as the best predictor of a stutterer's response to stuttering therapy, as determined by post-treatment clinical measures?

SUMMARY

The present study combined assessment procedures from the fields of speech pathology and neuropsychology to ascertain which variables were the best predictors of subject response to intensive stuttering therapy.

The establishment of a valid set of predictor variables for response to therapy would be both theoretically and clinically relevant. This study provides a starting point for further research and may allow for more appropriate treatment planning and client selection.

CHAPTER TWO: REVIEW OF LITERATURE

In this chapter, a review of literature is divided into two areas: predictive measures and assessment of therapy outcome.

A problem in the area of stuttering is the paucity of good predictive measures. This review will consider development of prognosis in speech therapy, examine traditional means for predicting outcome of therapy, and discuss the present status of predictive measures. It will explore new directions in prognosis and will discuss the possibility of other means of predicting therapy outcome. This review will be restricted to a discussion of the historical trends regarding stuttering and hemispheric processing, and will consider the problems inherent in its measurement. This will be followed by a discussion on how measures of brain functioning may serve as predictive measures and conclude with a description of the measures of interest in this study.

Since prediction of outcome necessitates evaluating treatment success, the second portion of this review will be devoted to a discussion of techniques used to estimate the amount of success in speech therapy. Prognostic values of predictor variables will be determined on the basis of these estimates.

PREDICTION OF OUTCOME

HISTORICAL BACKGROUND

IMPORTANCE OF PREDICTION

Prediction of outcome has long been considered an important factor in increasing effectiveness of treatment. Guitar (1976) proposed that valid predictor variables may be useful for three reasons: (1) they would permit treatment priority to be arranged according to likelihood of success in treatment, (2) they may highlight areas in which individualization of treatment is necessary if results are to be optimal, and (3) they may provide some insight into the nature of the disorder of stuttering.

After several decades of stuttering research, there are relatively few reported attempts to discover variables that are related to speech improvement in stuttering therapy (Lanyon, 1966; Van Riper, 1973). According to Hayhow (1983), the paucity of research on prognosis may be explained by "the inadequacy of our understanding of stuttering and the tendency for all stutterers to be grouped together and made to fit the available treatment programmes." (p. 23). Shames (1952) speculated that "the lack of description and definition of speech defectiveness in universally acceptable terminology" may be at the root of the problem.

Whether any view of stuttering as a single entity is misleading and different treatments are necessary for different cases or stuttering is a compound of many different and independent difficulties which must each receive separate therapeutic attacks (Beech & Fransella, 1968), there is as yet no clinically useful method for predicting which individual stutterer will improve with treatment.

TRADITIONAL MEANS

One of the first attempts to describe prognostic variables for stutterers was made by Bryngelson (1935). He referred to four variables that may serve as prognostic indicators: (1) sufficient intelligence to appreciate therapeutic goals and procedures, (2) determinedness, (3) necessary self-discipline to carry out therapeutic assignments, and (4) a satisfactory environment. If a client possessed these characteristics, Bryngelson suggested that prognosis for improvement in therapy was good. Unfortunately, these indicators are very subjective and difficult to measure.

In 1952, Shames investigated the value of biographical (eg. age, education, socio-economic status, and family history) and personality (eg. depression, social adjustment, attitude about the problem, and emotional adjustment) factors as predictors of success in speech therapy with 37 individuals exhibiting speech problems. The specific values for the personality factors were determined using a rating scale of unknown origin, the Guilford-Martin Inventory of Factors STDCR (Guilford, 1940), and the Rorschach test (Klopfer & Kelley, 1946). Shames found that 11 of 40 variables investigated showed a trend towards having some prognostic significance, however, 16 variables could have significance at the 10% level of confidence due to chance alone. Although the signs investigated were not significantly related to Shames' measure of change in speech adequacy, several signs were related to measures of change in social adjustment. Shames therefore argued that the study had value in suggesting certain refinements in the design of this type of research.

Similar findings were reported by Sheehan, Frederick, Rosevear, and Spiegelman (1954) with subjects who received "integrated" speech therapy consisting of the 'Iowa school' of avoidance-reduction therapy and eclectic psychotherapy. The authors set out to test the validity of the Rorschach Prognostic Rating Scale (Klopfer, Kirkner, Wisham, & Baker, 1951) by administering it to a population of 35 stutterers. The investigation showed that the Rorschach variables were related to psychotherapeutic improvement but not speech improvement. The authors concluded that the scale was not successful in predicting changes in overt speech behavior. However, it may indicate which stutterers are likely to drop out of therapy early and which stutterers will show the most psychotherapeutic improvement.

A study by Lanyon (1965) sought to determine whether high adaptation and low consistency scores were related to improvement in speech therapy. Lanyon used two measures of adaptation, the percentage & residual measures (Oxtoby, 1955; Quarrington, 1959), and one measure of consistency, the weighted percentage measure, with 33 stutterers enrolled in therapy at the Iowa Speech Clinic. Little or no evidence was found for a relationship between adaptation, determined with the residual measure, or consistency of stuttering while reading and later improvement in therapy. However, the author demonstrated that the amount of adaptation during oral reading, as determined by the percentage measure, was positively related to later improvement in stuttering therapy. Unfortunately, the relationship was not strong enough to be useful clinically. These findings were supported by Prins (1968) when he found that pre-treatment measures of stuttering adaptation were not clinically useful in predicting amount of change in stuttering during treatment.

In a later study, Lanyon (1966) investigated whether the same pre-therapy characteristics were present in subjects who showed improvement in stuttering therapy and subjects who showed improvement in psychotherapy. Pre-therapy characteristics were determined for 25 stutterers using portions of the Minnesota Multiphasic Personality Inventory (MMPI). Correlations between two of the four MMPI variables and improvement were significant in the predicted direction. However, the correlations concerned were not high and therefore only tentative comments could be made about the findings. It was suggested that persons who improve after stuttering therapy tend to be similar to persons who improve following psychotherapy; they are adaptable, resourceful, and are not basically deviant in personality or thinking patterns. Again, the relationship was not strong enough to be useful clinically. This seemed to be supported by the findings of Gregory (1969), Lanyon, Lanyon, and Goldsworthy (1979), and Perkins (1973). Gregory (1969) failed to find a significant correlation between MMPI, Holtzman Inkblot, or Edwards Personal Preference Schedule scores and change in treatment. As well, Lanyon et al. (1979), using the MMPI and Stuttering Severity Scale (Riley, 1972), found that global judgements of progress in therapy were only minimally related to actual progress in therapy. Finally, Perkins (1973) found no clinically meaningful relationships between personality measures (16 PF Test, Rorschach, and the Guilford-Zimmerman Temperament Survey) and treatment outcome.

In a study of the relationship between personal and social adjustment to speech improvement and post-therapy regression (Prins & Miller, 1973), results showed low correlations between therapy improvement, regression scores, and personality characteristics. However, a correlational trend suggested that treatment outcome could vary with personality adjustment.

More recently, Guitar (1976) analyzed the relationships between pre-treatment factors (stuttering behavior, personality, and attitudes) and post-treatment measures of stuttering behavior for 20 stutterers enrolled in a token economy stuttering treatment program (Ingham & Andrews, 1973). Personality was measured using the extroversion and neuroticism scales of the Eysenck Personality Inventory (Eysenck & Eysenck, 1963). Attitudes toward stuttering were measured using the short form of the Erickson Scale of Communication Attitudes (Erickson, 1969; Andrews & Cutler, 1974) and an abbreviated version of the Stutterer's Self-Ratings of Reactions to Speaking Situations (Johnson, Darley, & Spriesterbach, 1963; Cutler, 1973). Guitar found pre-treatment attitudes to be most highly related to outcome, followed by pre-treatment stuttering behavior, and lastly, personality measures.

In a later study, Guitar & Bass (1978) tested the hypothesis that stutterers who do not show a normalization of communication attitudes during treatment will have a poorer long term outcome. The authors used 20 subjects who had completed a token economy stuttering treatment program and on whom pre- and post-treatment modified Erickson Scale scores were available. Subjects with post-transfer scores of 9.0 or below were considered to be normalized in their attitudes, while subjects with post-transfer scores above 9.0 were not considered to be normalized. The post-treatment S-24 score was found to have a higher correlation with long-term outcome than change in score from the pre-to post-treatment. The authors postulated that the S-24 scale, administered at the end of the intensive phase of treatment, may be useful in planning further management.

Findings of Helps & Dalton (1979) were generally consistent with Guitar (1976). The authors, using a similar battery of assessments, found significant correlations between pre-treatment variables suggesting that "the more extrovert, less neurotic stammerer who has positive attitudes towards communication has a better prognosis, especially when the overall severity is not too great." (pg. 26). Contrary to findings of Guitar, the authors found pre-treatment frequency of stuttering to be the least important predictor of outcome.

Summary

Attempts to predict treatment outcome for individual stutterers have not produced clinically useful results. Use of psychometric procedures to assess personality factors have resulted in conflicting findings; some authors found no correlations between personality factors and treatment outcome (Shames, 1952; Sheehan et al., 1954) while others found small correlations (Gregory, 1969; Guitar, 1976; Helps & Dalton, 1979; Lanyon, 1966; Lanyon et al., 1979; Perkins, 1973; Prins & Miller, 1973), below the level to be considered clinically significant. This may be due to the lack of sensitivity of the presently available assessment procedures or a failure to measure the pertinent aspects of the stutterer (Hayhow, 1983).

NEW DIRECTIONS

THE SEARCH CONTINUES

The failure to find adequate predictors of success in therapy within our own field or that of psychology indicated that the search must continue into related fields. With recent investigations in the area of hemispheric processing and stuttering, measures that assess brain functioning may prove to be valid predictors.

CNS STUDIES

Recent findings regarding central nervous system (CNS) characteristics of stutterers pointed to the possibility of neurobiological aberrations in stutterers. Measures used in these investigations are considered below:

a) Dichotic Listening Studies

Dichotic listening, which involves simultaneous stimulation of both ears through stereophonic earphones with different stimuli of equal intensity, is probably the most familiar method of investigating hemispheric processing. This noninvasive measure of perceptual asymmetry and hemispheric specialization was developed by Broadbent in 1957 and popularized by Kimura in 1961.

Normal right-handed subjects typically obtained a right ear preference score for auditory-verbal material, reflecting a more direct neural pathway to language processing areas in the left hemisphere from the right than the left ear (Berlin & Lowe, 1972; Curry & Gregory, 1969; Kimura, 1961; Moore, 1984b; Moore & Weidner, 1975; Studdert-Kennedy & Shankveiler, 1970; Sussman & MacNeilage, 1975; Tsunoda, 1969; Tsunoda & Moriyama, 1972).

Studies utilizing meaningful linguistic stimuli usually reported a larger proportion of stutterers with a reduced right ear preference, a lack of ear preference, or a left ear preference (Curry & Gregory, 1969; Davenport, 1979; Perrin & Eisenson, 1970; Quinn, 1972; Sommers, Brady, & Moore, 1975). However, group differences in these studies often failed to be significant. These findings are consistent with those reported by Moore and Boberg (1987) in a review article of CNS studies. These results seem to suggest the possible existence of subgroups of stutterers in terms of hemispheric processing.

Studies employing nonsense syllables have not found results similar to those using meaningful stimuli (Blood, 1985; Brady & Berson, 1975; Cerf & Prins, 1974; Cimorell-Strong, Gilbert, & Frick, 1983; Dorman & Porter, 1975; Liebetrau & Daly, 1981; Pinksy & McAdam, 1980; Rosenfield & Goodglass, 1980; Sussman & MacNeilage, 1975).

b) Tachistoscopic Visual Studies

Tachistoscopy involves a visual procedure analogous to the dichotic studies auditory procedure.

Normal subjects typically show a right visual field preference for meaningful linguistic stimuli and a left visual field preference for nonlinguistic stimuli (Hines, 1972; McKeever & Huling, 1971a, 1971b; McKeever, Suberi, & VanDeventer, 1972; Moore, 1976; Moore & Weidner, 1974).

Studies with stutterers have all employed meaningful stimuli. Contrary to findings with normal subjects, stutterers evidenced a left visual half field preference (Hand & Haynes, 1983; Moore, 1976; Plakosh, 1978), implying right hemisphere activation (Moore & Boberg, 1987).

These findings were supported by a study of reaction times to visual stimuli (Wilkins, Webster, & Morgan, 1984), which demonstrated slower reactions to left visual field stimuli prior to treatment. However, following treatment, reaction times improved.

c) Sodium Amytal Injection Studies

Sodium amytal injections, more popularly known as the Wada technique, involve intracarotid injection of a general anaesthetic into the subject's dominant hemisphere so that he/she experiences transient aphasia as a result of temporary anaesthetization of the involved brain hemisphere. This invasive measure of 'speech dominance' was developed by Wada (1949) to locate speech centers prior to surgery.

In normal right-handed subjects, a temporary loss of language/speech was usually seen when the left carotid artery was injected, indicating that the left hemisphere is important for language functions.

Only a few studies utilizing this technique have been reported. In 1966, the results of Jones' study with four subjects sparked interest in the use of this technique in stuttering research. Jones reported that his subjects, all stutterers, became dysphasic following injection into either the right or the left carotid artery. This seemed to suggest that both hemispheres were contributing significantly to language. However, three of Jones' four subjects were left handed, increasing the likelihood of mixed dominance, and all had pre-existing cerebral pathologies, thus confounding the data.

Studies which have eliminated confounding variables (Andrews, Quinn, & Sorby, 1972; Luessenhop, Boggs, LaBorwit, & Walle, 1973) have failed to replicate Jones' findings of bilateral speech representation in stutterers with the Wada technique.

d) Cerebral Blood Flow Studies

The cortical blood flow (CBF) technique developed out of the observation that blood flow through body tissue changes as a direct result of metabolism and tissue activity (Lassen, Ingvar, & Skinhoj, 1978). Thus the more active hemisphere or regions of the brain would have greater regional cerebral blood flow. The CBF is determined in a noninvasive manner using elaborate detecting equipment. The subject is required to inhale a radioactive substance, Xenon-133, so that detectors placed on the scalp can monitor the internal radioactivity levels (Moore, 1984b).

Normal right-handed subjects evidenced greater CBF in the region of Broca's area in the left hemisphere during speech production and in Wernicke's area in the left hemisphere during speech reception.

Only one study utilizing this technique has been reported. Wood, Stump, McKeehan, Sheldon, and Proctor (1980) used the CBF method with two stuttering subjects. Recordings were made under two conditions: fluent (while under the influence of haloperidol) and stuttered (under normal conditions). Wood et al. reported higher Broca's area blood flow in the right compared to the left hemisphere and higher Wernicke's flow in the left compared to the right hemisphere for stuttered speech. However, the reverse was seen for fluent speech. These results were consistent with findings of Sussman and MacNeilage (1975), indicating conventional left cerebral dominance for speech reception but not speech production in stutterers. As well, they were consistent with the findings of Boberg et al. (1983) and McFarlane and Moore (1982), who reported a shift in hemispheric activation from the right to left hemisphere with improved fluency.

e) Electrophysiological Studies

The electroencephalogram (EEG) technique measures electrophysiological responses at the scalp to information processing by observing correlates of hemispheric activation over time (Moore & Boberg, 1987).

Studies in the late 1930's (Travis & Knott, 1936,1937; Travis & Malamud, 1937) and early 1940's (Douglass, 1943; Knott & Tjossem, 1943; Lindsley, 1940) revealed different alpha asymmetries for stutterers and normals and differences in total alpha amplitudes during speech.

The hemispheric alpha asymmetry procedure measures alpha brain wave amplitudes (8-13 Hz). An increase in brain activity in specific regions is reflected in a decrease in alpha amplitude in that region.

EEG measures have revealed a suppression of alpha brain wave frequency (8-13Hz) over the hemisphere involved in information processing (Dumas & Morgan, 1975; Galin & Ellis, 1975; Galin & Ornstein, 1972; Haynes & Moore, 1981a, 1981b; McKee, Humphrey, & McAdam, 1973; Moore, 1979; Moore & Haynes, 1980; Moore & Lang, 1977; Morgan, McDonald, & McDonald, 1971; Robbins & McAdam, 1974). In normal speakers, the suppression was over the left hemisphere during the processing of meaningful linguistic stimuli and over the right hemisphere for nonverbal information.

In early work with alpha suppression and stutterers, Moore and Lang (1977) found reversed lateralization with stutterers. The stuttering group showed greater suppression of alpha over the right hemisphere during the processing of linguistic stimuli. These findings were supported in later studies by McFarlane and Moore (1982), Moore, Craven and Faber (1982), Moore and Haynes (1980), and Moore and Lorendo (1980). As well, researchers reported a lower recall and recognition of words (Daly, 1981; Moore, Craven & Faber, 1982; Moore & Lorendo, 1980) by stutterers with a reduced right hemisphere alpha, but no reduction in comprehension of connected discourse (Moore & Haynes, 1980). This may reflect the right hemisphere's shorter verbal short-term memory span (Zaidel, 1979) and superiority in processing of semantic aspects of language (Moore, 1984b).

In a later study by Boberg, Yeudall, Schopflocher, and Bo-Lassen (1983), hemispheric alpha asymmetries were assessed pre- and post-treatment. Prior to treatment, stutterers showed greater alpha suppression over the right hemisphere, supporting findings of McFarlane and Moore (1982), Moore, Craven and Faber (1982), Moore and Haynes (1980), Moore and Lang (1977) , and Moore and Lorendo (1980). However, following treatment, greater alpha suppression was evident over the left hemisphere, similar to the pattern found in normal speakers. These findings seemed to suggest that increased fluency is associated with a shift in alpha suppression from the right to the left hemisphere.

More recently, Moore (1986) found a relationship between severity of stuttering and amount of hemispheric alpha asymmetry recorded during a verbal recall task. Moore noted a decrease in right hemispheric alpha concomitant with an increase in the frequency of stuttering, indicating that severity of stuttering may be related to the amount of right hemispheric activation during verbal tasks (Moore & Boberg, 1987).

The averaged evoked response (AER) technique involves measurement, by surface electrodes, of a waveform generated within the cortex in response to certain external and internal stimuli (Molfese, 1980).

In 1974, Zimmerman & Knott, utilizing a specialized form of AER called contingent negative variation (CNV), found that a larger proportion of stutterers than normals showed greater right hemisphere activation during verbal conditions. These findings were supported by Ponsford, Brown, Marsh, and Travis (1975). Using AER to investigate hemispheric differences between stutterers and normals, they found that stutterers showed greater differences in the right hemisphere during verbal tasks. Contrary to these findings were those of Pinsky and McAdam (1980). Using the CNV method with nonverbal stimuli, the authors found no differences between groups of stutterers and normals.

f) Dual-task Paradigm Studies

The left hemisphere is specialized for the control of sequential and temporal aspects of perception (Carmon, 1975; Halperin, Nachson, & Carmon, 1973) and complex, motor performance (Kimura, 1977; Kimura & Archibald, 1974; Mateer & Kimura, 1977), especially those involving upper limbs (Mateer, 1983). There is a close functional relationship between neural mechanisms associated with speech and those required for motor responses involving rapid transitions or sequences (Kimura, 1977; Lomas & Kimura, 1976). For this reason, concurrent tasks that involve the activation of the same or different hemispheres provide information regarding lateralization of brain function.

Concurrent verbal-manual tasks typically involve concurrent speech and finger tapping tasks. These tasks require the subject to tap telegraph keys using the fingers while speaking.

Finger tapping is known to be controlled by the contralateral cerebral hemisphere. Evidence suggests that rate of finger tapping will be reduced during concurrent speech and motor tasks if both activities are controlled by the same hemisphere

(Kantowitz & Knight, 1974; Kinsbourne & Cook, 1971; Kinsbourne & McMurray, 1975; White & Kinsbourne, 1980).

Several studies have used dual-task paradigms to measure interference effects displayed by stutterers and normals during speech. In comparing right-handed and left-handed finger tapping rates during speech, Sussman (1982) found that stutterers evidenced symmetric interference effects, suggesting a possible bilateral representation of speech. However, Brutten and Trotter (1985), using five dual-task finger tapping and vocalization conditions with right-handed stutterers, found no support for bilateral speech control.

In a later study by Brutten and Trotter (1986), the authors again found that school-aged stutterers responded like nonstutterers to a dual-task paradigm, though more slowly. Thus there was some support for the contention that neuromotor systems of stutterers may be less robust and more affected by the demands of speech production.

Likewise, in a bimanual writing task with right-handed adults, Fitzgerald, Cooke, and Greiner (1984) found no relationship between speech measures and handwriting performance for stutterers and nonstutterers. They did however find evidence in handwriting organization and accuracy to suggest that interhemispheric processes may have interfered with the stutterer's performance. The author's proposed that the normally lateralized speech mechanism of the left hemisphere would be vulnerable to interference from on-going right hemisphere activity if there was a gating failure between the two hemispheres. This notion was further supported by

Greiner, Fitzgerald, and Cooke in their 1986 replication study. Using right- and left-handed subjects, Greiner et al. found support for the hypothesis that disorganization in integration of the left and right hemispheric inhibitory and excitatory processes may be an integral component in stuttering.

Concurrent manual-manual tasks typically involve sequential finger tapping tasks. These tasks require the subject to tap telegraph keys sequentially using fingers of one hand, while conducting another task with the other hand.

It is assumed that depression of performance scores in finger tapping tasks reflect interference with the brain mechanisms needed to maintain sequential finger tapping (Moore & Boberg, 1987).

Webster (1985), utilizing index finger tapping and sequential finger tapping tasks, found no group differences between 16 male stutterers and 16 male controls. The author failed to find any general problems with sequencing or timing of behavior and interpreted results to suggest a normal lateralization of neural mechanisms associated with sequential processing. This interpretation was supported by Webster's (1986b) later findings using finger tapping movement sequences tasks. Webster again found that although stutterers evidenced no difficulty performing simple motor movements, they did produce more errors. As well, response initiation times were slower. Further evidence of slower reaction times in stutterers (Rastatter & Dell, 1987; Starkweather, Franklin, & Smigo, 1984) was found in children and adults (Cross & Luper, 1979) using auditory stimuli (Adams & Hayden, 1976; McFarlane &

Shipley, 1981), visual stimuli (Starkweather, Hirschman & Tannenbaum, 1976), galvanic skin response (Dinnan, McGuinness, & Perrin, 1970), and electromyographic recordings (McFarlane & Prins, 1978). Additional support for these findings were reported in a review article by Webster (1987). Thus, Webster's results provided further evidence for normal lateralization of sequential response mechanisms in stutterers with unusual susceptibility to interference.

Additional evidence for significantly more interference among stutterers was provided in a study by Webster (1986a). Using 16 male right-handed stutterers and 16 male right-handed fluent speakers in a concurrent task design (sequential finger tapping while performing another manual task), Webster found significantly more asymmetry in stutterers. He further speculated that the interference effect was not related to simple attentional mechanisms but reflects underlying neurological mechanisms. This theory of interference was consistent with findings of Fitzgerald et al. (1984) where they proposed a deficit in interhemispheric gating mechanisms as the possible origin of disfluencies.

g) Neuropsychological Test Battery Studies

Neuropsychology, "a science that attempts to correlate psychological and neurological facts" (Gove, 1981), provides assessment tools that indirectly measure hemispheric functioning by measuring observable behaviors.

The first neuropsychological battery to be used with stutterers was the Michigan Neuropsychological Test Battery (Smith, 1975). Several researchers, using this assessment tool, found evidence in the stuttering population of a high probability of cerebral and neurological dysfunction (Daly, Kimbarrow, & Smith, 1977; Smith & Daly, 1980). Further evidence of possible neuropsychological abnormalities in stutterers was found by Wolk (1986) and Strub, Black, and Naeser (1987).

In a later study, the Halstead-Reitan Neuropsychological Test Battery (H-RNTB) (Halstead, 1947; Reitan, 1959a) was used for differential assessment of stutterers (Boberg & Yeudall, 1984). The authors found significant differences on the H-RNTB between subjects–with whom therapy was successful versus those who were unsuccessful in therapy or in maintenance. It was therefore proposed that CNS function may be related to relative success in therapy (Moore & Boberg, 1987).

NEUROPSYCHOLOGICAL VARIABLES AS POSSIBLE PREDICTORS

Literature focusing on interhemispheric aberrations of stutterers pointed to a CNS functioning difference between stutterers and normals. This intrinsic difference may have profound effects on severity of stuttering as well as etiological and maintaining significance. Since neuropsychology is "the study of the relation between brain function and behavior" (Kolb & Whishaw, 1980, p. 111), its assessment tools may provide valuable predictor variables. To date, there have been no comprehensive reports of neuropsychological findings in stutterers and little work has been done to determine which tests or test batteries are most useful as measures to highlight neuropsychological abnormalities in the absence of structural anomalies.

TEST SELECTION

A vast number of individual tests and batteries of tests have been constructed for the purpose of identifying cerebral dysfunction. Probably the most widely used battery is the Halstead-Reitan Neuropsychological Test Battery (H-RNTB), originally constructed by Halstead (1947) and later refined by Reitan (1959a). This battery consists of a series of individual neuropsychological measures, which in combination, provide information about the integrity of the cerebral hemispheres. The H-RNTB samples observable behavior across cognitive, expressive, and motor functions, with the assumption that behavioral aberrations are the result of adaptive behaviors on the part of the brain. The literature seems to support this assumption, as the H-RNTB has been shown to be capable of differentiating between brain-damaged and normal adults (Klove, 1974), brain-damaged and normal children (Boll, 1974; Reitan,1974; Reitan & Boll, 1973; Selz & Reitan, 1979a,b), learning disabled and normal children (Reitan, 1964; Reitan & Boll, 1973; Selz & Reitan, 1979a,b) and learning disabled and normal young adults (O'Donnell, Kurtz, & Ramanaiah, 1983). As well, the H-RNTB has been found to have internal and test-retest validity (Bornstein, 1982, 1983; Matarazzo, Matarazzo, Wiens, Gallo, & Klonoff, 1976; Shaw, 1966), concurrent validity (Klove, 1974; Reitan, 1965, 1966), and to be unfakeable (Goebel, 1983; Heaton, Smith, Lehman, & Vogt, 1978).

The neuropsychological test battery used in this study consisted of 13 tests. Four tests were from the H-RNTB, intermediate level (valid for subjects nine to 14 years of age) and adult level (valid for subjects 15 years of age and older). These comprised: (1) the

Halstead Category Test, (2) the *Finger Tapping Test*, (3) the *Trailmaking Test A* and *B*, and (4) the three subtests of the *Tactual Performance Test* (*Time*, *Memory*, *Localization*). Four other well-known neuropsychological measures occasionally referred to as the Allied Procedures were utilized. These consisted of: (5) the *Dynamometer*, (6) the *Purdue Pegboard*, (7) the *Wisconsin Card Sorting Test*, and (8) a test of general intelligence, the *Multiple Aptitude Battery* . Five additional tests which have been utilized extensively with clients at Alberta Hospital completed the battery: (9) *Annett's Handedness Questionnaire*, (10) the *Symbol-Gestalt Test*, (11) the *Controlled Word Association Test*, and (12) the *Written Word Fluency Test*, and (13) the two subtests of the *Symbol Digit Modalities Test* (*Oral*, *Written*).[1]

These neuropsychological tests were selected on recommendation of Dr. L. Yeudall, Director of the Neuropsychology Department at Alberta Hospital, Edmonton. His suggestions were based on neuropsychological profiles generated from administration of over 30 tests to stuttering clients previously referred to Alberta Hospital.

TEST BATTERY DESCRIPTION

A detailed description of the tests which comprised the battery will follow.

I. LATERALITY MEASURE

A measure of lateral dominance was extremely important, as numerous neuropsychological tests required knowledge of hand preference prior to administration.

Annett's Handedness Questionnaire

Lateral dominance was measured using Annett's Handedness Questionnaire (Annett, 1967). This questionnaire provided an optimal measure of laterality due to its simplicity and minimal administration time.

II. MOTOR FUNCTIONING MEASURES

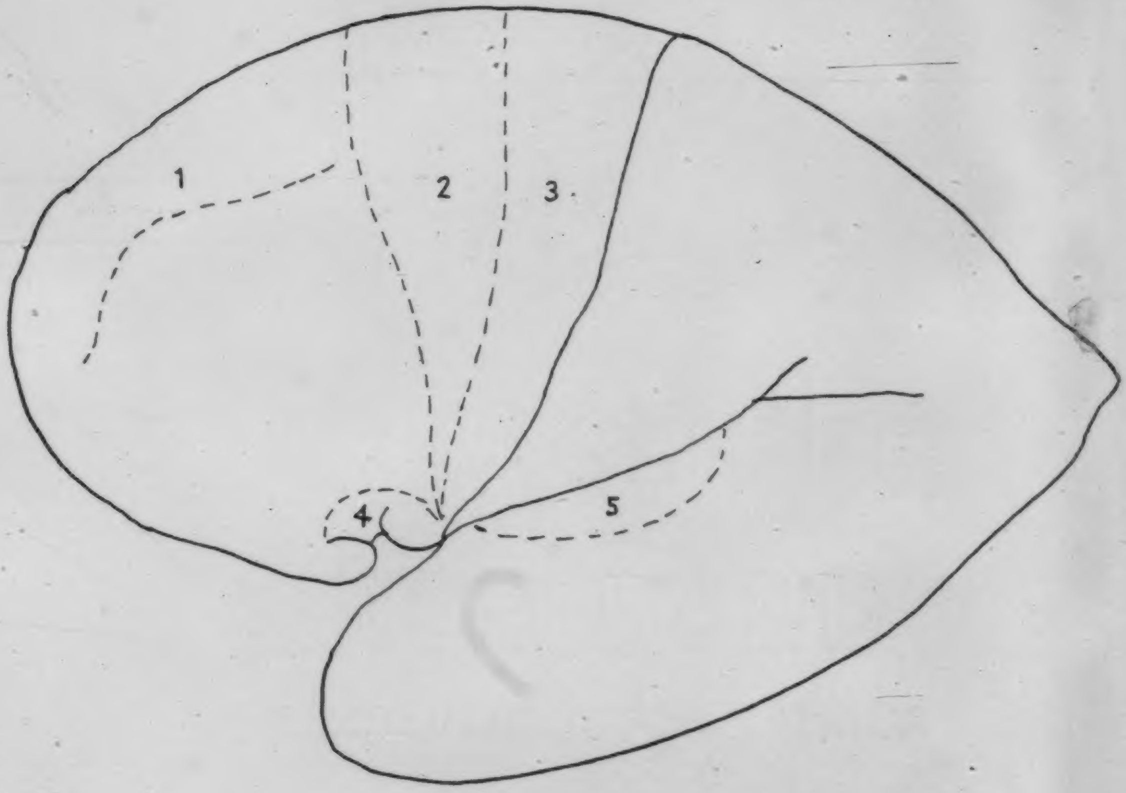
Motor functioning measures may be divided into two basic types: (1) those that assessed integrity of the primary motor region of the cortex and (2) those that assessed integrity of the premotor region of the cortex (Figure I). Tests that tapped functioning of the primary motor region involved pure motor activity with little cognition. These tests included the Dynamometer (a measure of motor strength), and the Finger Tapping Test (a measure of motor speed). Tests that tapped the functioning of the premotor region involved motor activity integrated with some higher level functioning. These tests included the Purdue Pegboard (a non-repetitive measure of manual dexterity), and the Trailmaking Test (a measure of motor speed and basic spatial skills).

Hand Dynamometer / Strength of Grip Test

Motor functioning was measured using the Dynamometer. The Dynamometer measures absolute strength in the upper extremities, as well as a left / right comparison. Generally, the preferred hand should have been 10% stronger than the nonpreferred hand (Reitan & Wolfson, 1985). Reddon, Stefanyk, Gill, and Renney (1985) reported

FIGURE 1

LATERAL SURFACE OF THE LEFT HEMISPHERE SHOWING THE FUNCTIONAL AREAS TESTED BY THE NEUROPSYCHOLOGICAL MEASURES



Note: 1= prefrontal area, 2 = premotor area, 3 = primary motor area, 4 = Broca's area, 5 = primary auditory area trial and session effects for the test, and thus recommend that it be administered near the beginning of the battery. However, due to the reduced number of tests used in the current study, this was not considered to be a confounding variable.

This measure assessed integrity of the primary motor region of the cortex and involved pure motor activity and little, if any, cognition. The Dynamometer thus provided a pure, direct measure of strength of the motor system. It has been shown to be effective not only in discriminating between brain damaged and normal subjects but has also proven useful in the identification of lateralized lesions (Dodrill, 1979).

Finger Tapping (FTT) / Finger Oscillation Test

Motor functioning was also measured using the Finger Oscillation Test (Halstead, 1947) or, as it was later renamed, the Finger Tapping Test (FTT). The FTT measured right / left manual agility and motor speed and thus provided a means of testing contralateral neuromotor capacity (Brutten & Trotter, 1985; Hughes & Sussman, 1983). This test involves the use of fine motor control, kinesthetic ability, and visuomotor coordination. Several studies (Dodrill & Troupin, 1975; Gill, Reddon, Stefanyk, & Hans, 1986; Morrison, Gregory, & Paul, 1979) have shown the FTT to be reliable over time. Gill et al. (1986) reported trial and session effects for the test and recommended that it be administered near the beginning of the battery due to fatigue factors. Sex differences were found on the FTT due to the size of men's hands and muscles (Chavez, Trautt, Brandon, & Steyaert, 1983; Dodrill, 1979; Gordon & O'Dell, 1983; King, Hannay, Masek, & Burns, 1978; Maccoby & Jacklin, 1974) but these differences were not significant according to Yeudall, Reddon, Gill, and Stefanyk (1987).

It has been claimed (Golden, 1978; Golden, Osmon, Moses, & Berg, 1981) that impaired performance on the FTT may reflect dysfunction of the primary motor area, premotor area, or parietal lobe. This measure of motor activity was acclaimed as one of the most sensitive tests for brain damage, especially when the damage is lateralized (Russell, Neuringer, & Goldstein, 1970).

Purdue Pegboard

Motor functioning was also measured using the Purdue Pegboard Test (Purdue Research Foundation, 1948). This test, although it provides another measure of rapid repetitive-type movements, requires different motor skills than the FTT. It measures manual dexterity, motor speed and laterality.

The Purdue Pegboard assessed the integrity of the primary motor region of the cortex and involved motor activity with little cognition.

Trailmaking Test

Another test of motor functioning was the Trailmaking Test, which was originally developed as part of the Army Individual Test Battery (Adjutant General's Office, 1944). This test provides a measure of a completely non-repetitive type movement. It measures visuospatial scanning ability, motor and sequencing skills, and visuomotor tracking abilities. It involves the use of motor speed, basic spatial skills, counting ability, mastery of the alphabet, sustained concentration, mental flexibility, and the ability to mentally sequence stimuli. Of interest in subject selection and response analysis were findings of Yeudall, Fromm, Reddon, &

Stefanyk (1986). Results suggested age differences for the preferred hand and sex differences across all measures, as well as age effects for Trail B (Yeudall et al. 1987).

This measure assessed the integrity of the primary motor region of the cortex. Trail A is considered, by some researchers, to be more a measure of right hemisphere integrity , while Trail B is considered to be more indicative of left hemisphere intactness (Golden et al., 1981).

III. SPATIAL-PERCEPTUAL ORGANIZATION MEASURE

A measure of spatial-perceptual organization was extremely important to a neuropsychological test battery as a battery should be complete enough to tap all areas of brain functioning without overlap. The TPT in particular is an extremely valuable measure since it not only taps the spatial-perceptual organization but incidental learning as well.

Tactual Performance Test (TPT) / Tactual Form Board

Spatial-perceptual organization was measured using the TPT (Halstead, 1947), which is an adaptation of the Seguin-Goddard Form Board from the Arthur battery of tests (1947). The TPT measures spatial analytic ability, motor speed, tactile and kinesthetic ability, and learning in the absence of visual cues. It has been shown by many researchers to be the most reliable measure in the H-RNTB (Matarazzo et al. 1976; Matarazzo, Wiens, Matarazzo, & Goldstein, 1974). As well, it is a reliable measure of incidental nonverbal learning (DeRenzi, Faglioni, & Scotti, 1968; Lezak, 1983). Yeudall et al. (1987) found age effects for the 'both hand' time scores, memory scores, and localization score. However, they noted no sex effects on the TPT, contrary to the findings of Chavez, Schwartz, and Brandon (1982), Gordon and O'Dell (1983), and Kupke (1983).

The TPT was found to be among the most sensitive measures for differential diagnosis of brain damaged and normal subjects (Goldstein & Shelly, 1972; Heaton, Chelune, & Lehman, 1978; Newhan, Heaton, & Lehman, 1978; Schreiber, Goldman, Kleinman, Goldfader, & Snow, 1976; Vega & Parsons, 1967). The TPT is purported to be a valid indicator of lateralization of brain damage (DeRenzi, 1978; Reitan, 1964; Russell, 1974).

IV. ABSTRACTIVE ABILITIES MEASURES

Measures of abstractive abilities or concept formation were used to assess the integrity of the prefrontal region of the brain (Figure I). The WCST focuses primarily on lesions or other pathological conditions in the frontal lobes, while the HCT is an overall indicator of functioning.

Halstead Category Test (HCT)

Abstractive abilities were measured using the HCT (Halstead, 1947). This test involves visual memory, visuospatial reasoning, short-term memory and the ability to concentrate and maintain attention for a protracted period of time. The HCT has excellent internal consistency (Moses, 1985) and nonsignificant sex and age effects (Yeudall et al., 1987).

Writers have claimed that impaired performance on the HCT may reflect dysfunction of the prefrontal cortex (Golden et al., 1981) or a lack of generalized cerebral integrity (Reitan & Wolfson, 1985). It is an overall indicator of pathological conditions with good validity in that it can be used to differentially diagnose brain damaged and normal subjects (Doehring & Reitan, 1962; Shaw, 1966). The HCT is sensitive to focal nonfrontal cerebral lesions or diffuse cerebral lesions regardless of location (Reitan, 1955, 1959b; Robinson, Heaton, Lehman, & Stilson, 1980). One study found a direct variation of error scores with severity of brain damage (Shaw, 1966).

Wisconsin Card Sorting Test (WCST)

Abstractive abilities were also measured using the WCST (Berg, 1948; Grant & Berg, 1948). The WCST taps different abilities than the HCT and thus was not clinically interchangeable (Bond & Buchtel, 1984; Pendelton & Heaton, 1982; Rothke, 1986). It measures concept formation and perseverative tendencies. An age effect was noted by Berg (1948) and Loranger & Misiak (1960), however, contradictory results were found by Yeudall et al. (1986). An order effect was noted by Brandon & Chavez (1985) if the HCT preceded the WCST. In the testing administered at Alberta Hospital, the HCT precedes the WCST, therefore in order to provide consistency, the same order was maintained for subjects tested at the Institute for Stuttering Treatment and Research (ISTAR).

The WCST was found to be more sensitive to focal lesions that involve the frontal lobes than to nonfrontal lesions (Bornstein, 1986; Drewe, 1974; Heaton, 1981; Milner, 1963; Robinson et al., 1980), especially the prefrontal region of the cortex.

V. SEQUENTIAL PROCESSING MEASURES

Sequential processing measures, like the abstractive abilities measures, assessed the integrity of the prefrontal region of the cortex (Figure I). The sequential processing measures are less global, however, and provide a more lateralized assessment of brain functioning; the Symbol-Gestalt Test is specific to right cortex, while the Symbol-Digit Modalities Test is specific to left cortex.

Symbol-Gestalt Test

Sequential processing abilities were measured using the Symbol-Gestalt Test (Stein, 1962, 1970). It measures visual scanning, visuomotor coordination, and visual association memory. Yeudall et al. (1986) found age and sex differences, while Stein (1962) found no indication of a significant sex difference.

The Symbol-Gestalt test is sensitive to lesions in the right prefrontal and left parietal regions (Royce, Yeudall, Bock, 1976; Yeudall et al., 1986).

Symbol Digit Modalities Test

Sequential processing abilities were measured using the Symbol Digit Modalities test (Smith, 1968). The Symbol Digit Modalities test, although similar to the Symbol-Gestalt Test and Digit Symbol subtest from the Wechsler Adult Intelligence Scale - Revised (WAIS-R), does not replicate them (Yeudall et al., 1986). The Symbol Digit Test measures visual scanning, visuomotor coordination, and visual association memory. Yeudall et al. (1986) found age and sex differences for both versions of the test. Normative data are available for children (Lewandowski, 1984; Smith, 1973), young adults aged 15 to 40 years (Yeudall et al., 1986), and adults (Lezak, 1983; Smith, 1982).

This test assesses the integrity of the prefrontal region of the left hemisphere. It has been shown to have good predictive validity with brain-damaged adults (Smith, 1982) and has been proven a useful screening device for children (Lewandowski, 1984).

VI. WORD RETRIEVAL MEASURES

Word retrieval tests provide a measure of integrity of the speech centers. Broca's area, in the left hemisphere (Figure I), is assessed using the Controlled Word Association Test and the posterior inferior frontal regions of the right hemisphere are assessed using the Written Word Fluency.

Controlled Word Association Test

Verbal word retrieval was measured using the Controlled Word Association Test (Benton & Hamsher, 1978); part of the Benton battery and included in the Multilingual Aphasia Examination.

Numerous studies have found that a lesion in the left frontal lobe, Broca's area, produced a decrement in functioning on the word retrieval tests (Benton, 1968; Milner, 1964; Perret, 1974; Raimer & Hecaen, 1970). They also found that the disability appeared, independent of the mode of expression. It was determined that there existed with the Controlled Word Association Test, a verbal factor, primarily controlled by the left hemisphere, and a factor of spontaneity and initiative, primarily controlled by the frontal lobes (Perret, 1974; Ramier & Hecaen, 1970). Findings seemed to indicate that performance on verbal and non-verbal fluency tasks were age but not sex-dependent (Benton,1973; Borod, Goodglass, & Kaplan, 1980; Yeudall et al. 1986).

Written Word Fluency

Word retrieval was also measured using the Written Word Fluency Test (Lezak 1983; Yeudall, 1983). It measures non-verbal word retrieval.

The Written Word Fluency test assesses integrity of the posterior inferior frontal regions of the cortex, especially the right hemisphere.

VII. GENERAL INTELLIGENCE MEASURE

General intelligence measures assessed integrity of the posterior regions of the cortex (Figure I). Thus the intelligence measures are fairly global measures of brain functioning.

The importance of evaluation of general intelligence with stutterers has been questioned by many researchers. Some researchers believe that stuttering is more prevalent among the above-average intelligence population (Fruewald, 1936). Others report a higher prevalence in the retarded population (Andrews & Harris, 1964; Schlanger & Gottsleben, 1957; Travis, 1931; Wallin, 1949; Williams, Melrose, & Woods, 1969; Wohl, 1951). Still a third group of researchers found inconclusive results or no significant difference between prevalence of stuttering in normal and retarded populations (Boberg, Ewert, Mason, Lindsay, & Wynn, 1978; Carlson, 1946; Darley, 1955; Goodstein, 1958; Holmes & Pelletier, 1967; Johnson, 1946; Martyn, Sheehan, & Schultz, 1969; Schindler, 1955; Sheehan, Martyn, & Kilburn, 1968). These findings are consistent with those of Bloodstein (1987) and Boberg (1977), reported in review articles of stuttering in the retarded population. These conflicting data have created uncertainty regarding the useful of intelligence testing with stutterers. Clearly, further research regarding the relationship between intelligence and stuttering is indicated.

Multiple Aptitude Battery

Intellectual functioning of subjects 16 years of age and older was measured using the Multiple Aptitude Battery (Jackson, 1985), a computerized version of the Wechsler Adult Intelligence Scale - Revised (WAIS-R; Wechsler, 1981). Subjects under 16 years of age were assessed using the appropriate age-equivalent form for children, the Wechsler Intelligence Scale for Children - Revised (WISC-R; Wechsler, 1974). This test measures cognitive rather than motor abilities. Questions consist of: factual inquiry questions, mathematical problems, synonym matching questions, definitional questions, symbol-digit matching questions, picture completion questions, figure matching tasks, sequencing questions and object assembly questions. A 15 year stability study of neuropsychological test results (Sarazin & Spreen, 1986) showed high and significant correlation coefficients across time for the intelligence testing, even though there was a change in test form from the children's to the adult version.

The MAB assesses the integrity of the posterior regions of the brain and involves numerous cognitive abilities.

ASSESSMENT OF OUTCOME

PURPOSE

Prognostic value of the independent variables was determined on the basis of the dependent variables, clinical measures which were administered pre- and post-treatment. These were explored as possible predictors when coupled with neuropsychological scores.

MEASURES USED

Rationale and description of the clinical assessment measures used in this study will follow.

I. SEVERITY OF STUTTERING MEASURES

Evaluation of severity depends on several factors (Ham, 1986). Frequency of stuttering and speaking rate were selected for use in this study, as they are most frequently used in current therapies (Boberg & Kully, 1985; Curlee & Perkins, 1984; Guitar & Peters, 1980; Ingham, 1984) and they constitute a portion of the routine clinical assessment at ISTAR. Specifically, the clinical measures of %SS and SPM were demonstrated to show high reliability and correlation with listener's judgements of severity (Young, 1975; Andrews & Ingham, 1971).

Frequency and syllable counts have long been recognized as a source of great discrepancy (Kully & Boberg, in press), however, research has indicated that these counts can be made with satisfactory levels of agreement (Curlee, 1981; Young, 1969; Young & Downs, 1968). Costello and Ingham (1984) stated that "percentage agreement between total counts is generally the more convenient and useful indicator of measurement reliability." (p. 311). This was supported by earlier findings of Young (1975), that observers are more likely to agree on total counts rather than on individual moments of stuttering in prescribed periods of speech.

Frequency of Stuttering

One of the most popular and most sensitive measures of stuttering is frequency of occurrence (Costello & Ingham, 1984). Frequency of stuttering correlates highly with judgements of severity of stuttering (Bloodstein, 1987; Sander, 1961; Dalton & Hardcastle, 1977) and was most commonly reported as percentage of syllables stuttered (%SS). [2] To capture the variability inherent in the disorder of stuttering, researchers generate %SS scores from numerous samples of stutterer's speech gathered under as many conditions as possible (eg. reading, conversation).

Overall Rate of Speech

A second popular measure of severity of stuttering is speech rate which indicates the extent to which stuttering disrupts the ongoing flow of speech (Ingham, 1984). Similar to %SS, overall rate of speaking, measured by the number of syllables spoken per minute (SPM), correlates highly with judgements of severity of stuttering (Sander, 1961). Additionally, it has been shown that speaking rate and oral reading rate are negatively correlated with stuttering frequency (Ingham, 1984). Thus the overall speaking rate provides a measure of speaker efficiency (amount of information the speaker conveys in a given period of time, including pause time due to formulation difficulties or moments of stuttering).

II. ATTITUDINAL MEASURE

Evaluation of a stutterer's attitude towards his own speech has been the source of frequent debate. Due to the prevalence of conflicting data in this area, many clinicians have questioned the value of assessing attitudes.

Stutterer's attitudes about their speech problems were recognized as a basic dimension of the stuttering problem as early as the 1940's. (Ammons & Johnson, 1944; Johnson, Brown, Curtis, Edney, & Keaster, 1956; Travis, 1957; Van Riper, 1954). Early efforts to evaluate attitude were plagued with problems in establishing reliability. The first of such measures was the 'Iowa Scale of Attitude toward Stuttering' (Ammons & Johnson, 1944), followed by the 'Stutterer's Self Ratings of Reactions to Speaking Situations' (Shumak, 1955). As alluded to previously, there was little in the way of published data regarding reliability and validity for these scales. Consequently they were used primarily as guides in clinical interviewing rather than standardized assessment tools (Johnson, Darley, & Spriesterbach, 1963).

The 'Perceptions of Stuttering Inventory' (PSI) was developed by Woolfe in 1967 to measure quantitatively a stutterer's anticipatory reactions. The PSI provides an indirect measure of the degree of understanding the subject has of his/her stuttering problem and thus may aid in identification of subjects who experience a lot of denial. As well, the PSI may be useful in assessing improvements in a stutterer's behavior (Andrews & Cutler, 1974), as the subject is instructed to check statements which characterize him at that moment, thus allowing a comparison of PSI responses across time.

The S-24 Scale

The Erickson S-scale (Erickson, 1969) provides an index of the extent to which a stutterer's communication attitudes deviate from 'normal' attitudes. Responses of 50 stutterers and 100 nonstutterers on a Communication Inventory of 100 items were compared. Responses that differentiated stutterers and nonstutterers formed the basis of this empirically derived 39-item scale of communication attitudes, the S-scale. Erickson (1969) reported high positive relationships between the S-scale and self- and clinician-ratings of stuttering severity. In a validation study, Andrews and Cutler (1974) reported that the S-scale was unsuitable for repeated administration because of low intrasubject reliability. Fifteen items identified as unsuitable for repeated administration were deleted from the original S-scale and a revised short form, the S24 scale, was published. The S24 is a more reliable and valid measure of change in communication attitudes of stutterers. Numerous researchers (Andrews and Cutler, 1974; Guitar, 1976; Guitar & Bass, 1978; Helps & Dalton, 1979; Silverman, 1980) utilized the S24 Scale as a measure of stuttering severity. One trend was clear in the data from these studies; there were inconsistencies between subjects' S24 Scale scores and other severity measures such as percentage of syllables stuttered and syllables spoken per minute. Despite these inconsistencies, people have found it useful as a predictor. However, Ingham (1979) and Ulliana and Ingham (1984) raise the issue as to whether or not the scores reflect changes in attitude or are dependent on variations in stuttering frequency in the situations.

Erickson (1969) also reported high positive relationships between the S-scale and self-ratings of improvement in therapy. These findings were supported by other researchers (Andrews & Cutler, 1974; Guitar, 1976; Guitar & Bass, 1978) and it was postulated that the S24 may be useful in predicting long-term therapy outcome (Guitar & Bass, 1978). Yet, findings by Ulliana and Ingham (1984) contradicted these results and indicated that it was premature to conclude that attitudinal factors played a critical role in therapy outcome.

The abundance of conflicting reports have created uncertainty regarding the validity of an attitudinal measure with stutterers. Clearly, further research regarding the relationship between attitudinal measures (such as the S24) and therapy outcome is needed.

III. SPEECH QUALITY MEASURE

In recent years, there has been a move towards evaluation of treatment outcome, not only in terms of post-treatment severity, but in terms of speech quality as well. Scales have been devised which require listeners to rate speakers in terms of speech naturalness. Previously, it had not been recognized that, as Costello and Ingham (1984) stated, "speech that is free of stutterings and that displays appropriate overall and articulatory rates may or may not be speech that sounds like 'normal speech' to listeners. That is, there is yet another dimension of speech production that is only partially overlapped by these other measures: a measure of the quality of speech." (p. 315).

Over the years, there was an accumulating body of literature supporting the notion that, for various treatments, differences noted in 'treated speech' of stutterers versus natural speech of nonstutterers were due to subtle differences in speech quality (Barber, 1940; Clark, 1964; Johnson & Rosen, 1937; Runyan & Adams, 1978). Yet, little research was directed toward evaluation of speech quality produced by different treatment programs (Onslow & Ingham, 1987). It was not until the early 1980's that there was a revived concern over validity of outcome measures used to evaluate current stuttering therapies (Bloodstein, 1987; Boberg, 1981; Ingham, 1984).

Speech Naturalness

In the first attempt to measure speech naturalness, Nichols (1966) assessed naturalness in the sentences of normal speakers. Later, speech quality measurements were applied to stutterers. Unfortunately, the time-consuming and complicated nature of the procedures reduced the functional importance of these studies (Costello & Ingham, 1984). The first such study was completed by Jones and Azrin (1969) to measure the effect of various durations of vibrotactile rhythmic signals on stutterers, using a 'natural' or 'unnatural' judgement. Mallard and Meyer (1979) required listeners to rate treated and untreated stutterer's speech samples on a scale from 'most' to 'least preferred speech pattern'. Ingham and Packman (1978) required listeners to make natural/unnatural judgements and judge fluency, prosody and speaking rate in order to distinguish between stutterer's and nonstutterer's speech samples. Runyan and Adams, employing both sophisticated (1978) and unsophisticated (1979) listeners, required listeners to differentiate fluent speech samples of stutterers from those of nonstutterers. Findings of Ingham and Packman (1978) and Runyan and Adams (1978,1979) indicated that listeners were able to confidently distinguish between fluent speech of stutterers and nonstutterers.

In the first truly practical approach to measurement of speech quality, Martin, Haroldson, and Triden (1984) developed a scale to quantify the speech quality identified in stuttering therapy as naturalness. They employed a 9-point scale (1 = highly natural sounding speech to 9 = highly unnatural sounding speech), acclaimed to have construct validity and reliability. They required 30 naive listeners to rate audio recordings of 1-minute speech samples from three types of speakers: 10 stutterers, 10 normal speakers, and 10 stutterers speaking fluently under the influence of delayed auditory feedback (DAF). Results seemed to indicate that: (1) "observers (could) attend to and quantify a dimension of speech labelled as speech naturalness" (p. 57), and (2) ratings of speech naturalness were highly correlated with percentage of words stuttered and number of words spoken. More importantly, results indicated that listeners were able to rate speech naturalness with high inter-judge and intrajudge reliability scores.

A later study by Ingham, Gow, and Costello (1985), utilizing the 9-point scale devised by Martin et al. (1984), found relatively low correlations between listeners' decisions as to whether a sample sounded natural or unnatural and whether the sample was from a stutterer or nonstutterer. Thus, "listeners (judged) a speaker to be unnatural sounding but also normally fluent" (Onslow & Ingham, 1987, p. 11-12), which was consistent with the findings of Ingham and Packman (1978).

In summary, there is evidence that naturalness ratings have been clinically useful and provide an additional component to a clinical assessment of stuttering.

FOOTNOTES

[1] The descriptions of the neuropsychological tests were compiled from Barth & Macciocchi, 1985 (p. 381-397); Gilandas, Toruyz, Beaumont, & Greenberg, 1984 (p. 91-148); Golden, Osmon, Moses, & Berg, 1981(p. 1-15); Swiercinsky, 1978 (p.38-95); and Whitworth, 1984 (p. 305-314).

[2] Frequency of stuttering was most often reported in terms of syllables because it controlled for fluctuating syllable output. Syllable counts were preferable for a variety of reasons: (1) syllables were considered to be the basic physiological units of utterances (Costello & Ingham, 1984), (2) they allowed for the possible occurrence of stuttering on more than one syllable in a word, and (3) syllable counts were unaffected by variations in word length (Umeda & Quinn, 1980).

CHAPTER THREE: METHODOLOGY

SUBJECTS

Subjects in this study were 17 male stutterers drawn from two groups of clients treated at the Institute for Stuttering Treatment and Research (ISTAR): (1) client population at ISTAR in 1987 and (2) clients who received treatment at ISTAR prior to 1987 (and had appropriate pre-treatment neuropsychological testing). Subjects were unpaid, volunteer participants. Selection criteria were:

1. All subjects received intensive stuttering therapy at ISTAR (see Appendix A for a brief description of the treatment program).
2. All subjects were nine years of age or older.[1]
3. All subjects were male since there are known sex differences in: (1) interpersonal communication styles of men and women (Eakins & Eakins, 1978), which may have affected their response to pre- and post-treatment speech measures, (2) stuttering dynamics (Silverman & Zimmer, 1979), which may have affected their response to therapy, and (3) neuropsychological performance (Chavez et al.,1982; Chavez et al., 1983; Dodrill, 1979; Gordon & O'Dell, 1983; King et al., 1978; Kupke, 1983; Maccoby & Jacklin, 1974; Yeudall et al., 1987), which may have affected the score obtained on neuropsychological measures.

All clients in ISTAR who met the above criteria received a letter inviting participation in this study (Appendix B). With the exception of subjects who received therapy and neuropsychological testing prior to 1987, selection of subjects was on a volunteer basis. Subjects who were tested prior to 1987 constituted a special case in that a referral for neuropsychological testing was requested by a speech-language pathologist at ISTAR, based on a concern regarding their potential for progress in stuttering treatment. It is understood that this subject population was neither homogeneous nor did it constitute a random sample. Although this reduces generality, results should still serve to increase the present knowledge base regarding neuropsychology and stuttering. Thus, with the exception of two subjects, no attempt was made to preselect subjects for demographic, disorder severity, or performance level variables. Seventeen subjects met the inclusion criteria (p. 45). The average patient was a right handed (82%), high school educated (mean (M) = 12.353 years, standard deviation (SD) = 4.821, range = 17), young adult (M = 24.941 years, SD = 11.093, range = 33). Subjects presented with pre-treatment frequency of stuttering ranging from 0% to 53.96% and pre-treatment rate of speech ranging from 23.89 syllables per minute (SPM) to 233.06 SPM. In addition, one subject presented with characteristics typically associated with cluttering (monotonous, rapid, jerky, repetitive, indistinct speech (Weiss, 1964)), however, this was a purely subjective diagnosis made by the investigator.

PROCEDURES

All subjects signed the informed consent document (Appendix G) prior to inclusion in the study. The consent form briefly outlined the nature of the neuropsychological testing, the subjects' rights as a volunteer, and the time commitment required. Routine clinical consent forms were obtained from subjects authorizing the release of information (Appendix H) and release of audio and videotaped speech samples (Appendix I) for inclusion in this study.

All subjects were assessed individually using clinical speech and neuropsychological measures. Clinical speech measures were administered to each subject on two occasions; prior to therapy and immediately following the completion of the therapy program. Neuropsychological measures were administered on one occasion only, however, testing may have extended over more than one session. Neuropsychological tests, excluding the intelligence test, were administered prior to the third day of therapy. Since the intelligence test measures attributes assumed to be stable, this test was administered any time during the treatment period.

ADMINISTRATION OF NEUROPSYCHOLOGICAL MEASURES

The neuropsychological measures, in combination with the pre-treatment clinical speech measures, constituted the independent or predictor variables. In the previous chapter, these measures were reviewed with regard to development, issues, administration controversies, and usefulness. In this section, general administration procedures will be outlined, followed by identification of the measures used and data generated, and concluding in a discussion of reliability.

GENERAL ADMINISTRATION

The neuropsychological test battery was administered in accordance with the instructions of Yeudall (1983). Testing for independent variables was completed by the third day of therapy before speech changes began to occur.

Testing was administered by a neuropsychological technician from Alberta Hospital or the experimenter. The experimenter was trained in test administration at Alberta Hospital. Prior to commencement of the research, the experimenter passed a training procedure at Alberta Hospital which involved the procedures outline above.

Order of administration in the H-RNTB was not standard across subjects because previous investigation had shown that, when properly administered, the order in which tests were presented did not significantly affect the subject's performance (Neuger, O'Leary, Fishburne, Barth, Berent, Giordani, & Boll, 1981). Neuger et al. (1981) further recommended that the administration order be altered to maximize subjects' cooperation.

MEASURING INSTRUMENTS

(1) Annett's Handedness Questionnaire

This questionnaire was developed by Annett (1967) to quantify hand preference for subjects of all ages. The subject was required to respond verbally to a series of 12 questions (Appendix F) designed to determine hand dominance.

The reported hand was recorded for each of the items and the dispersion of the answers was examined. Depending on the distribution, one of the following ratings was assigned: 'strong right', 'inconsistent right', 'mixed right', 'mixed left', 'inconsistent left', 'strong left', or 'both'.

(2) Hand Dynamometer

The dynamometer is an instrument which measures the subject's strength of grip. The subject was required to hold the instrument in his hand and squeeze the handle. Each subject was given two trials alternately for the dominant and non-dominant hand. After each trial, the kilograms pulled were recorded and the pointer was reset.

The scores achieved on the Dynamometer were the average kilograms pulled by each hand. These two scores were labelled: the preferred hand score, **'DYP'**, and the non-preferred hand score, **'DYNP'**. In both subtests, a high score is a positive score and a low score is a negative score. A third score, a laterality measure, was derived as follows: **'DY' = 'DYP' - 'DYNP'**.

(3) Finger Tapping Test (FTT)

The FTT was developed by Halstead (1947) to measure right /left manual agility and motor speed. The subject was required to tap a telegraph-type key (a lever mounted on a board connected to a mechanical counter) using only the index finger, while the device recorded the number of taps performed in a 10-second period. The subject completed a minimum of five acceptable trials with each hand. To be acceptable, the trials had to produce scores within five taps of each other; if this was not the case, additional trials were conducted until the criterion was met. A complete set of appropriate trials were accomplished with the preferred hand before beginning with the second hand.

Final scores for the FTT were averages of the five selected trials for each hand. These two scores were labelled: the preferred hand score, **'FTP'**, and the non-preferred hand score, **'FTNP'**. In both subtests, a high score is a positive score. A third score, a laterality measure, was derived as follows: **'FT' = 'FTP' - 'FTNP'**.

(4) Purdue Pegboard

The Purdue Pegboard test was developed by the Purdue Research Foundation (1948) to measure manual dexterity and motor speed. This timed test was completed in four separate trials. In the first trial, the subject was required to remove pegs from a cup one at a time and place them in a row of holes on a board using only his preferred hand. On the second trial he performed the same task using his non-preferred hand. Trial three involved the same task, however two rows of holes were filled simultaneously, using both hands. The final task again involved both hands but required an alternating motion as assemblies of peg+washer+collar+washer were created by switching hands as each new part of the assembly was added.

The scores generated from the Purdue Pegboard Test included: the number of pegs inserted by each hand independently, the number of pegs inserted in pairs, and the number of assemblies created. The first score, **'PPP'**, was the preferred hand score. The second score, **'PPNP'**, was the non- preferred hand score. The third score, **'PPB'**, was the number of pairs of pegs inserted using both hands. The fourth score, **'PPA'**, was the number of assemblies created. In all four subtests, a high score is a positive score. The final score, **'PP'**, was the laterality score derived from **'PPP' - 'PPNP'**.

(5) Trailmaking Test

The Trailmaking Test was developed by the Adjutant General's Office (1944) as a measure of visuospatial scanning and visuomotor tracking abilities. It consisted of two subtests, each preceded by a sample. Subtest A involved the connecting of randomly dispersed circles containing numbers in the correct chronological order. In Subtest B, the subject was required to connect randomly dispersed circles containing numbers and letters in the correct chronological and alphabetical order, alternating between numbers and letters.

Trailmaking Test results were expressed in terms of time in seconds to complete each sample. For both time scores, labelled **'TR A'** and **'TR B'**, a low score is positive.

(6) Tactual Performance Test (TPT)

The TPT was developed by Arthur (1947) and later adopted by Halstead (1947). It provided a measure of spatial analytic ability, tactile and kinesthetic ability, and incidental learning. The subject was required to insert wooden blocks into their respective holes in a board while blindfolded. The subject was required to complete three separate trials: Trial 1 with the preferred hand, Trial 2 with the non-preferred hand, and Trial 3 with both hands. Following this, the subject was asked to draw the board from memory with all the shapes in their correct location on the board.

The scores generated from the TPT included a time score in seconds for each hand independently and the two hands together, a memory score for the number of blocks remembered (thought by Russell, 1974, to be a bilateral measure of brain functioning), and a localization score for the number of blocks remembered in the correct position on the board (thought by Russell, 1974, to be a measure of right hemispheric functioning). The first score, **'TPP'**, was the preferred hand score. The second score, **'TPNP'**, was the non-preferred hand score. The third score, **'TPB'**, was the time to insert the blocks using both hands together. In these three subtests, a low score is positive. The fourth score, **'TPM'**, was the number of block shapes recalled correctly. The fourth score, **'TPL'**, was the number of blocks recalled in their correct location. For these two measures, a high score is positive. The final score, **'TP'**, was the laterality score derived from **'TPP' - 'TPNP'**.

(7) Halstead Category Test (HCT)

The HCT was developed by Halstead (1947) to measure performance reflecting dysfunction of the prefrontal cortex or a generalized lack of cerebral integrity. The subject was required to evolve a single principle from visual presentations of geometric shapes and colors. Specifically, the subject observed visual stimuli presented on a screen and respond by pressing one of four buttons to indicate what number the stimuli suggested.

The score generated from the HCT indicated the total number of errors made. For this score, **'HCT'**, a low score is positive.

(8) Wisconsin Card Sorting Test (WCST)

The WCST was developed by Berg (1948) to measure the subject's perseverative tendencies. The subject was required to match cards, one at a time, to one of four model cards. The subject had to discover the correct matching criterion based on tester feedback. No matching guidelines were provided, and the rules of matching changed intermittently throughout the test without notice to the subject.

The score generated from the WCST indicated the total number of errors made. For this score, **'WISC'**, a low score is positive.

(9) Symbol-Gestalt Test

The Symbol-Gestalt Test was developed by Stein (1962, 1970) to measure visual scanning, visuomotor coordination, and visual association memory. The subject was required, using a key which matches numbers and abstract figures, to copy the abstract figures onto a page in the correct order.

The scores generated from the Symbol-Gestalt test consisted of: the number of items completed in three minutes, the percentage of errors in the first 40 items, and an improvement score calculated from the first to third minute. These three scores were converted, using a conversion table based on a standardization sample, into one derived score, **'SG'**. For this test, a low score is positive.

10) Symbol-Digit Modalities Test

The Symbol-Digit Modalities Test was developed by Smith (1968) to measure visual scanning, visuomotor coordination, and visual association memory. This test was presented twice; once in a verbal form and once in a written form. The subject was required, using a key which matches abstract figures and numbers, to copy the numbers onto a page in the correct order.

Scores generated from the Symbol-Digit Modialities Test consisted of: the number of items completed correctly for each version of the test. For both these subtests, **'SDO'** and **'SDW'**, a high score is positive.

A third score, a verbal/nonverbal difference score, was derived as follows: **'SD' = 'SDO' - 'SDW'**.

11) Controlled Word Association Test

The Controlled Word Association Test was developed by Benton and Hamsher (1978) to assess verbal word retrieval. The subject was required to say as many words as he could that began with a certain letter. This test was repeated for each of several letters.

The score generated from this oral word fluency test consisted of an average of the number of words produced in each trial. For this score, **'OWF'**, a high score is a positive.

12) Written Word Fluency

The Written Word Fluency Test was developed by Lezak (1983) and Yeudall (1983) to measure non-verbal word retrieval. The subject was required to write as many words as he could that began with a certain letter. This test was repeated for each of several letters.

The score generated from this written word fluency test consisted of an average of the number of words produced in each trial. For this score, **'WWF'**, a high score is positive. A second score, a verbal/nonverbal difference score, was derived as follows: **'WF' = 'OWF' - 'WWF'**.

13) Multiple Aptitude Battery (MAB)

The MAB was developed by Jackson (1985) to assess a variety of verbal and non-verbal skills. The subject was required to work independently on a computer to complete this test. The test was divided into two general sections (verbal intelligence and performance intelligence), each containing five subtests.

The verbal subtests included: information, comprehension, math, similarities, and vocabulary. The information subtest consisted of factual inquiry questions sampling the subject's general knowledge. The comprehension subtest consisted of questions requiring the subject to determine what should be done or what is required in a given situation. The arithmetic subtest consisted of mathematical problems presented to the subject to be worked out with paper and pencil only. The similarities subtest consisted of questions requiring the subject to select the word which was most similar to the word provided. In the vocabulary subtest, the subject was presented with stimulus words and asked to match them for their meaning.

The performance subtests included: digit symbol, picture completion, spatial, picture arrangement, and object assembly. The digit symbol subtest was a coding task that required the subject to match symbols to the digits from 1 to 9. The picture completion task required the subject to determine, for each picture presented, what important piece was missing. The spatial task required the subject to rotate figures in his mind in order to determine which figure matched the model provided. The picture arrangement subtest consisted of sets of pictures that were presented to the subject out of order. The subject was required to select the correct order, from left to right, such that they formed a sensible story. In the object assembly subtest, the subject was presented with pictured pieces of common objects to be assembled. The subject was required to order the puzzle pieces in his mind to determine the correct order to properly assemble the object.

The scores generated from the MAB consisted of the number of correct responses for each of the ten subtests. These raw scores were converted into derived scores based on a standardization sample used as a base. These derived scores were converted into three intelligence quotient (IQ) scores, each with a mean of 100 and a standard deviation of 15 (Zachary & Gorsuch, 1985), for purposes of statistical analysis. The verbal IQ score was labelled **'VIQ'**, the performance IQ score, **'PIQ'**, and the full scale IQ, **'FSIQ'**. For these three measures, a high score is positive. A fourth score, a verbal/nonverbal difference score, was derived as follows: **'IQ' = 'VIQ' - 'PIQ'**.

RELIABILITY

All neuropsychological evaluations were administered by a person who was qualified to administer the battery. Swiercinsky (1978) outlined the following set of procedures for training technicians:

1. Technicians must have minimum educational qualifications of a bachelor's degree in psychology or a related area with at least an introductory course in test construction and administration.
2. The student technician is administered a complete battery by a trained examiner.
3. The student technician watches an experienced technician or neuropsychologist administer the battery to a patient and then scores it.
4. The student technician is provided test manuals for study as well as time in the examination labs to become thoroughly familiar with all test materials.
5. Sufficient one-to- one contact with the neuropsychologist is

> offered to help the student master administration and scoring methods.
>
> 6. When sufficiently practiced in both administration and scoring, the student technician administers a complete battery in the presence of the supervising neuropsychologist. If the administration is smooth, natural, and accurate and scoring is done properly, the technician is certified as competent. (p. 33).

ADMINISTRATION OF CLINICAL SPEECH MEASURES

A variety of clinical speech methods were selected for assessing the speech of a stutterer. These focused on the assessment of the severity of stuttering, attitudes about stuttering, and speech quality. Two reliable measures which correlate highly with ratings of severity are: (1) the frequency of stuttering, expressed as percentage of syllables stuttered (%SS), and (2) the overall rate of speech, expressed as syllables spoken per minute (SPM) (Andrews & Ingham, 1972a,b).

Stutterer's attitudes toward communication were measured by the modified Erickson Scale of Communication Attitudes (S24 Scale), and speech quality was measured by a speech naturalness rating (Martin et al., 1984).

These clinical speech measures constituted the dependent or criterion variables, and were used as independent or predictor variables in combination with the neuropsychological measures. In the previous chapter, the clinical speech measures were reviewed with regard to development, issues, administration controversies, and usefulness. In this section, general administration procedures of this study will be outlined, followed by a discussion of the measures used, data generated, and reliability calculated.

GENERAL ADMINISTRATION

To obtain the four clinical speech measures, subjects were requested to perform two tasks.[2] The first task required completion of the S-24 Scale, while the second involved a three-minute video recording of a conversation and a three-minute video recording of a reading speech sample.

The three-minute recordings of each subject's speech during a conversation and reading task was obtained in the presence of an interviewer who was a stranger to the client.[3] The interviewer was provided with a list of questions (eg. "Tell me about yourself.") and a copy of a reading passage. The interviewer was instructed to obtain a three-minute sample of each subject's speech during a conversational task and an additional three-minutes during a reading task. The video-recording of the samples was completed by a trained technician who operated the recorder and signalled the interviewer when the time had passed.

Scoring of the speech samples was completed at a later date and involved three procedures: (1) counting the number of syllables on which a stutter was judged to have occurred, (2) counting the total syllables spoken during speaking time, and (3) rating of the naturalness of 15-seconds of the conversational speech sample. From these procedures, the percentage of syllables stuttered, the syllables spoken per minute and the speech naturalness rating were determined.

MEASURING INSTRUMENTS

(1) Percentage of Syllables Stuttered (% SS)

Frequency-counts of stuttered syllables were made for each subject in accordance with the syllable and stuttering counting instructions (Appendix C) outlined for ISTAR. Counts were made on each of the four speech samples (pre-treatment conversation, pre-treatment reading, post-treatment conversation, and post-treatment reading).

Counting of the number of syllables on which a stutter was judged to have occurred and the total syllables spoken during speaking time in the videotaped speech samples was completed by the experimenter. The experimenter is a trained listener with five years of academic studies in speech pathology and three years of experience working with stutterers.

Individual %SS scores for each speech sample were calculated by dividing the total number of stutters by the total number of syllables spoken and multiplying the result by one hundred. These four scores were combined to form two scores. The scores included: (a) %SS pre-treatment, **'%SS1'**, determined by averaging the %SS obtained during the conversation and reading conditions; and (b) %SS post-treatment, **'%SS2'**, determined by averaging the %SS obtained during the conversation and reading conditions. For both scores, a low score is positive.

(2) Syllables Spoken per Minute (SPM)

Overall speaking rate was determined for each subject in accordance with the syllable counting and timing instructions (Appendix

C) outlined for ISTAR. Rate estimates were completed for each of the four speech samples (pre-treatment conversation, pre-treatment reading, post-treatment conversation, and post-treatment reading). Counting of total syllables spoken and speaking time in the videotaped speech samples was completed by the investigator.

Individual SPM scores were calculated by dividing the total number of syllables spoken by the total time (in seconds) and multiplying the result by sixty. These four scores were combined to form two scores. The scores included: (a) SPM pre-treatment, **'SPM1'**, determined by averaging the SPM obtained in the conversation and reading conditions; and (b) SPM post-treatment, **'SPM2'**, determined by averaging the SPM obtained in the conversation and reading conditions. For both scores, a high score is positive.

(3) S-24 Scale

The S-24 Scale (Erickson, 1969; Andrews & Cutler, 1974) was used to assess the stutterer's attitude towards communication. A number of investigators (Andrews & Cutler, 1974; Guitar, 1976; Guitar & Bass, 1978; Helps & Dalton, 1979; Silverman, 1980) have reported that it provides a measure of attitude independent of characteristics of the subject's speech behavior.

The S-24 Scale (Appendix D) was self-administered, with each subject completing the paper-and-pencil test in accordance with the original instructions of Andrews & Cutler (1974).[4]

The subject's total score was derived from the total of item responses that were indexed as 'scored' responses. 'Scored' responses were those responses which were made significantly more often by stutterers than nonstutterers. 'Nonscored' responses were those that were made significantly more often by nonstutterers than stutterers (Erickson, 1969). Two scores were generated for each subject: (a) S24 pre-treatment, **'S241'**, and (b) S24 post-treatment, **'S242'**. For both scores, a low score is positive.

(4) Speech Naturalness Ratings

A speech naturalness rating scale was used to obtain ratings of each speaker's speech quality. This technique has been reported to enable listeners to rate speech naturalness with high interjudge and intrajudge reliability (Martin et al., 1984).

Speech naturalness ratings were made on dubbed pre- and post-treatment conversational speech samples for each subject. The naturalness rating task was set up in accordance with the general procedures outlined by Martin et al. (1984), with the exception of the length of segment to be analyzed. In contrast to the 1-minute segments of Martin et al. (1984) and the 30-second segments of Ingham, Martin, Haroldson, Onslow, and Leney (1985), 15-second segments of speech (Ingham & Onslow, 1985) were utilized in this study. The shorter speech samples enabled the investigator to select a speech segment in such a way that it was representative of the speaker; yet excessive pause time, identifying information (eg. subject's name or information indicating that the subject was involved in a stuttering treatment program) and interviewer interruptions were eliminated. The segments of speech (two for each subject) were randomized and dubbed onto a master tape with seven seconds of silence separating each sample and a recorded number preceding it, to indicate its chronological position.

Three naive listeners served as raters. Raters were given a packet of sheets containing instructions and the necessary 9-point rating scale (Appendix E). Time was allotted for each listener to peruse the instructions and all questions were addressed by the examiner. After the instructions were read, a cassette recorder was activated and the 36 audiotaped speech samples were played non-stop.

Scores for each subject were determined by averaging the naturalness ratings assigned by each listener. Two scores were generated for each subject: (a) pre-treatment naturalness rating, **'NAT1'**, and (b) post-treatment naturalness rating, **'NAT2'**. For both scores, a low score is positive.

RELIABILITY

(1) %SS and SPM

Intrajudge reliability, for the examiner, was determined based on eight counts (pre-treatment %SS conversation, pre-treatment %SS reading, pre-treatment SPM conversation, pre-treatment SPM reading, post-treatment %SS conversation, post-treatment %SS reading, post-treatment SPM conversation, post-treatment SPM reading) for each of three subjects. Subjects were ordered alphabetically and reliability counts were completed on the first three subjects selected at random. These counts occurred at least a week after the initial counts. From the eight counts, four values were determined, these included: pre-treatment %SS, pre-treatment SPM, post-treatment %SS, post-treatment SPM. Reliability calculations were performed using a correlation test across the subjects and conditions (pre- and post-treatment). Intrajudge reliability was $r = .988$ for %SS and r = .987 for SPM (Table I). Overall reliability was thus r = .9875.

Interjudge reliability, to establish the extent of agreement between two listeners on judgements of stutters and syllable counts, was determined by comparing the experimenter's judgements with those of another experienced speech-language pathologist. Three subjects were again selected from the random ordering of subject data. The reliability judge was provided with a packet of counting instructions (Appendix C) and instructed to count the number of stutters, the number of syllables, and the time elapsed (in seconds). Judges results were again compared using a correlation test. Interjudge reliability was r = .992 for %SS and r = .856 for SPM (Table I). Overall reliability was thus r = .924.

TABLE I

SUMMARY OF INTERJUDGE AND INTRAJUDGE RELIABILITY FOR %SS AND SPM

	Rater #1		Rater #2	
	%SS	SPM	%SS	SPM
Rater #1				
%SS	r = .988		r = .992	
SPM		r = .987		r = .856

(2) S-24 Scale

Reliability and validity of the S-24 Scale as a repeated administration measure were clearly established by Andrews and Cutler (1974).

(3) Speech naturalness ratings

Intrajudge reliability, indicating the extent to which raters assigned similar scale values to a given speech sample on two occasions, was determined following the initial rating session. Each listener rated five randomly selected 15-second speech samples on a second separate occasion, at least a week after the completion of the initial session. Rater reliability was determined in terms of rate-rerate agreement. Reliability calculations for each of the ratings was determined using a correlation test. Reliability was calculated separately for each rater. Intrajudge reliability for the raters was as follows: r = .927 for rater #1, r = -.850 for rater #2, and r = .988 for rater #3 (Table II).

Interjudge reliability, indicating the extent to which all raters assigned the same naturalness scale value to a given speech sample, was determined. Reliability was calculated for all possible paired combinations of raters for each of the five samples. The results were in terms of correlation coefficients. Overall interjudge reliability for the paired judges may be seen in Table II. Interjudge reliability between rater #1 and rater #3 was the highest agreement achieved, however, reliability was still considered to be low.

TABLE II

SUMMARY OF INTERJUDGE AND INTRAJUDGE RELIABILITY FOR NATURALNESS RATINGS

	Rater #1	Rater #2	Rater #3
Rater #1	r = .927		
Rater #2	r = .499	r = -.850	
Rater #3	r = .724	r = .257	r = .988

DATA ANALYSIS

A variation of a correlational design was utilized in this study. If a linear relationship existed between two variables, the correlational design would allow the prediction or estimation of a score on one variable from the knowledge of a score on another variable. In neuropsychology, "it is usually preferable to use a combination of several relatively homogeneous tests, covering a different aspect of the dependent variable, rather than a single test consisting of a hodgepodge of many different kinds of items" (Anastasi, 1968, p. 146). A multiple regression analysis in Statview 512+ (Feldman, Gagnon, Hofmann, & Simpson, 1986) was utilized. Multiple regression analyses yielded equations having the best possible linear combination of a number of independent or predictor variables predicting each dependent or criterion variables. For each regression analysis, one of the post-treatment clinical measures was selected as a criterion variable. Neuropsychological and pre-treatment clinical measures served as the predictor variables.

Criterion variables consisted of: %SS2, SPM2, S242, and NAT2. The predictor variables consisted of: DYP, DYNP, DY, FTP, FTNP, FT, PPP, PPNP, PPB, PPA, PP, TRA, TRB, TPP, TPNP, TPB, TPM, TPL, TP, HCT, WISC, SG, SDO, SDW, SD, OWF, WWF, WF, VIQ, PIQ, FSIQ, IQ, %SS1, SPM1, S241, and NAT1.

FOOTNOTES

[1] The intermediate level of the neuropsychological test battery is valid for subjects 9 -14 years of age and the adult level is valid for subjects 15 years of age or older.

[2] The S-24 Scale and the fluency measures (including the conditions under which they were recorded) constitute the regular assessment procedures of the Boberg-Kully program, and as such were only briefly described here. For a more detailed description of these measures, consult Boberg and Kully (1985).

[3] Subject's under 12 years of age have their speech samples recorded in the presence of a clinician, not a stranger. This was the case for two of the subjects in this study.

[4] Subject's under 12 years of age do not complete this scale. In this study, two subjects were below administration age.

CHAPTER FOUR: RESULTS

STATISTICAL ANALYSIS

In order to answer the research question stated in Chapter I, an analysis was required which would allow the measurement of the combined effect of two or more independent or predictor variables on one dependent or criterion variable. For this purpose a multiple regression analysis was chosen.

The discussion in this section will be divided into three main sections. Section 1 will focus on concepts central to an understanding of multiple regression analysis. These will include: assumptions of a linear regression model, description of the regression equation, information regarding the use of beta weights and suppressor variables in the derivation of the regression equation, interpretation of the correlation coefficient, and interpretation of the analysis of variance table. In section 2, an account will be given of the stepwise procedure for multiple regression analysis. Section 3 will raise some issues regarding interpretation of the results.

MULTIPLE REGRESSION

The basic statistical theory of multiple linear regression is the same as that of the simple linear regression. A linear function fitted to data for two variables is referred to as a straight line; a linear function for four or more variables is called a hyperplane. A regression analysis is concerned with: (1) deriving an equation that provides estimates of the criterion from values of two or more predictor variables, (2) obtaining measures of the error involved in using the regression equation as a basis for estimation, and (3) obtaining a measure of the proportion of variance in the criterion accounted for by the predictor variables (Hamburg, 1983).

While the multiple linear regression simply extends the bivariate regression, the computational problems of handling a large number of variables simultaneously would be prohibitive without the assistance of a specialized computer program. Statview 512+ (Feldman, Gagnon, Hofmann, & Simpson, 1986) was utilized in this study to carry out the multiple regression and correlation analyses.

ASSUMPTIONS

Usual assumptions of a linear multiple regression analysis include:

1. the data be at last interval quality of measurement (Lutz, 1983).
2. the Y values are assumed to be independent of each other (Hamburg, 1983); and
3. there is a normal distribution of Y for every combination of the values of X in the model (Hamburg, 1983; Norusis, 1982).

THE REGRESSION EQUATION

The regression equation is: $Y = a + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k$, where the constant 'a' is the Y intercept and the beta values act as weights (Hamburg, 1983). Given a criterion, the linear-regression problem is to estimate weights β_1, β_2, ...β_k, and the constant 'a' such that the regression equation provides a good estimate of an individual's Y score based on his X scores. The least-squares method is used to estimate the beta weights. The least-squares method finds βs in such a way that the sum of the squared prediction errors, the difference between an individual's Y score and the one predicted (Y'), is kept as small as possible (Willemsen, 1974).

In the regression equation, each predictor variable is weighted in direct proportion to its correlation with the criterion and in inverse proportion to its correlations with other predictors. Thus, the highest weight is assigned to the predictor that has the least amount of overlap with the rest of the predictors (Anastasi, 1968). Similarly, the value of the multiple correlation coefficient (R) increases as the size of correlations between criterion and predictor variables increases, and decreases as the size of intercorrelations of predictor variables increases. Prediction by means of a multiple linear regression is most successful when the intercorrelations among predictors is low and the correlation between each predictor and the criterion is moderate. Under these circumstances, the independent contribution of each predictor is optimized. (Guilford & Fruchter, 1978; Willemsen, 1974).

BETA COEFFICIENTS

The beta values are referred to as 'net regression coefficients'. The net effect of one predictor is the effect it has on the criterion when all other predictors are held constant. For instance, the β_1 coefficient measures the change in Y per unit change in X_1 when all other X's are held fixed (McElroy, 1979). In general, when there were more than two predictors, it is difficult to determine the relative contributions of the predictors in predicting the criterion by simple inspection of the multiple-regression weights. Since variables often differ in their units of measurement, the magnitude of the coefficients is not a good index of relative importance. As well, values of beta coefficients are contingent on the other predictor variables and are affected by their intercorrelations. (Guilford & Fruchter, 1978; Norusis, 1982; Willemsen,1974).

SUPPRESSOR VARIABLES

Under certain conditions the predictive quality of a predictor variable can be improved (increased R^2) by including in the regression equation a predictor which correlates well with another predictor, but not with the criterion variable. This is known as a 'suppressor variable' because it acts to eliminate or suppress the irrelevant variance in the other predictor. The suppressor variable thus appears in the regression equation with a weight opposite that which would be presumed (eg. although it may correlate positively with the criterion, it may appear in the regression equation with a negative beta weight) (Anastasi, 1968; Guilford & Fruchter, 1978; Willemsen, 1974).

CORRELATION COEFFICIENT

The predictive adequacy of the set of beta weights can be found by computing a measure of covariability. This special Pearson correlation coefficient is called the 'coefficient of multiple correlation' (R). The 'coefficient of multiple determination' , symbolized R^2, measures the percentage of criterion variance that is accounted for by all the predictor variables combined (Guilford & Fruchter, 1978; Hamburg, 1983). For example, from Table VI, we can say that 70.00% of the variance in the post-treatment %SS was accounted for by whatever was measured by the TPL, DYP, SG, and TR A taken together. The remaining variance, which is 30.00% (1 - R^2), is still to be accounted for. This remainder is known as the 'coefficient of multiple nondetermination'. (Guilford & Fruchter, 1978)

The coefficient of multiple determination also provides a means of assessing the relative importance of the predictor variables. This is accomplished by examining the increase in R^2 when a variable is entered into an equation that already contains the other predictor variable(s). A large change in R^2 indicates that a variable provides unique information about the criterion variable not available from other predictor variables in the equation. Caution must be used, however, in basing interpretation of the importance of a variable on the increase in R^2 alone. This value only tells how much R^2 increases when a variable is added; it does not indicate what proportion of the unexplained variation the increase constitutes. If most of the variation has already been explained by other variables, a small increase in R^2 is all that is possible for the remaining variable (Norusis, 1982).

ANALYSIS OF VARIANCE (ANOVA) TABLE

The total sum of squares (SS) is expressed as the sum of the regression (or explained) sum of squares and the residual sum of squares (SS). The total SS represents the sum of squared deviations of the criterion variable Y values from their mean; regression SS represents the sum of squared deviations of the fitted values of Y around their mean and residual SS represents the sum of the squared residuals. The total SS is calculated only from the values of the criterion and consequently it remains unchanged throughout the calculation of the regression. The regression SS increases at each stage and the residual SS decreases at each stage of the regression as the number of predictor variables brought into the analysis increases. When the regression relation is a good fit, the regression SS is large relative to the residual SS. The nearer the ratio regression SS ÷ total SS is to one, the better the fit. In multiple regressions, this ratio is written as R^2. Thus, as the number of predictor variables brought into the analysis increases, so does the R^2 value. It was another matter, however, whether or not the increase in the goodness of fit is 'statistically significant' (Cooper & Weekes, 1983).

The F test associated with the ANOVA table is a test of the null hypothesis that all the β values are equal to zero (H_0: $\beta_1=\beta_2=\beta_3 \ldots\ \beta_k = 0$). It is a test of whether or not the regression relation as a whole is significant; whether there is a linear relationship between the criterion variable and the set of predictor variables (Norusis, 1982). If the null hypothesis is valid, two alternative estimates of a model variance parameter can be calculated from the data: (1) regression mean square = regression SS ÷ *df* , (2) residual mean square = residual SS ÷ *df* . The ratio 'regression mean square' ÷ 'residual mean square' is given under the heading *F* . This *F* -value is the test statistic for the null hypothesis. If the null hypothesis is valid, then the *F* ratio is distributed according to the F distribution with $df_1 = k-1$ and $df_2 = n-k$, where 'k' is the number of constants in the regression equation (betas + a) and 'n' is the number of cases. The decision rule is: if $F\ (df_1, df_2) > F_{obtained}$, reject the null hypothesis; if $F\ (df_1, df_2) \leq F_{obtained}$, do not reject the null hypothesis (Cooper & Weekes, 1983).

The Statview 512+ program performs an *F* test at an investigator-assigned alpha level upon the addition of each new predictor variable. Any variables not meeting this level of significance are automatically deleted from the regression. Thus, an ANOVA of the final regression equation provides little additional information regarding the significance of the findings.

STEPWISE MULTIPLE REGRESSION

To get a better idea of the independent contribution of each of the predictor variables, some investigators add them into the equation one by one, computing betas and R^2 at each step. This technique is known as 'stepwise multiple regression' (Willemsen,1974). Stepwise selection of predictor variables is probably the most commonly used procedure in regression analysis. It allows the investigator to generate a statistical answer to the question of whether or not an added variable contributes enough to predictors already in the composite to justify its inclusion. As well, through the use of forward selection, stepwise regression analysis has the added advantage that it reduces the number of possible sets of variables to be scrutinized from 2^k-1 (8,589,934,600 in this study) to k (33 in this study). Where 'k' is the number of predictor variables (Cooper & Weekes, 1983).

The stepwise procedure is really a combination of the forward and backward procedures. It begins with no variables in the equation. At the first stage, the computer determines which of the predictor variables has the largest positive or negative correlation with the criterion variable. The variable with the highest partial correlation is inserted (forward selection) in the model if its partial *F* exceeds the investigator-assigned *F* -to-Enter level (3.0 was used as the entry level in this study). After the insertion of a variable, any variable currently in the model is examined for removal (backward elimination) based on whether its partial *F* is less than the investigator-assigned *F*-to-remove level (2.99 was used as the exit level in this study). To prevent the same variable from being repeatedly entered and removed, *F*-to-enter is set at a value greater than *F*-to-remove. At the next stage, the predictor variable that accomplishes the greatest reduction in the remaining unexplained variance is inserted into the model. The computer finds the multiple R for the combination of the two best predictors and does an *F* test to determine whether the new R is significantly greater than the correlation without the last addition. The computer printout displays an ANOVA table at each stage. Additional variables enter and leave the equation in the same manner. The addition of variables ceases when the probability of the obtained *F* rises above an adopted alpha level (in this study, the alpha level was set at .01). In other words, the procedure stops when no variables currently in the equation can be removed and the variable with the highest partial correlation, not in the equation, fails the *F* -to-Enter test (Guilford & Fruchter, 1978; Hamburg, 1983; Norusis, 1982).

ISSUES

POST FITTING CHECKS

Residuals generated from the predicted regression equation should be plotted in order that: they may be examined for evidence of normality (Norusis, 1982), the magnitudes of prediction errors may be examined, and the investigator may check for evidence of departures from regression model assumptions (Hamburg, 1983). Specifically, the investigator should check for:

1. evidence that individual predictor variables did not enter linearly into the regression equation, and
2. suggestions that the individuals whose values were used in the fitting process did not constitute a homogeneous group.

(Cooper & Weekes, 1983)

MULTICOLLINEARITY

As mentioned previously, when predictor variables are highly correlated, it is not possible to separate individual effects of predictor variables on the criterion variable. When two or more predictor variables are correlated with each other, they are said to be 'multicollinear'. There are two ways in which multicollinearity can be detected. Large coefficients in the correlation matrix always signal the presence of multicollinearity; however, a correlation coefficient close to 0 is another indicator of near-singularity (Norusis, 1982).

Multicollinearity, depending upon its degree, can cause several practical problems. When predictors are highly correlated among themselves: (1) there is little predictive value (increase in R^2) gained by adding more predictors to the regression equation, and (2) the standard errors of regression coefficients may be very large, causing the precision of estimates to be very low (Cooper & Weekes , 1983; Norusis, 192; Willemsen, 1974).

POPULATION CORRELATION COEFFICIENT

The multiple correlation coefficient (R) represents the maximum correlation between a criterion variable and a weighted combination of predictor variables for a particular sample. It does not represent an unbiased estimate of the population correlation coefficient. The least - squares method for estimating coefficient weights, capitalizes on idiosyncrasies of the sample that favor high multiple correlation. The multiple R is therefore an inflated value. It is a biased estimate of the multiple correlation in the population (Ferguson, 1976). The extent of the bias is inversely related to the sample size and directly related to the number of predictor variables (Anastasi, 1968; Willemsen, 1974). Formulas are available for estimating the amount of 'shrinkage' in a multiple correlation to be expected when the regression equation is applied to a second sample or a population. One such formula for 'shrinking' R to a more probable population value is given by the formula $R'^2 = 1- (1- R^2)\ (n-1 \div n-m)$ where 'n' = number of cases in the sample, 'm' = number of variables correlated, 'n-m' = number of degrees of freedom (Guilford & Fruchter, 1978).

SUMMARY OF RESULTS

Results are reported in five sections. Section 1 discusses descriptive statistics for the variables. Raw data are presented in Appendix J and a key to capitalized abbreviations for the variables appears in Table III. In section 2, results of multiple regression analyses are discussed. In section 3, analyses of the post-fitting checks of residuals created by each regression equation are reported. Section 4 presents correlation matrices and looks at the possibility of multicollinearity.

TABLE III

KEY TO ABBREVIATIONS FOR CRITERION AND PREDICTOR VARIABLES

%SS2 = Average frequency of stuttering (post-treatment)
SPM2 = Average rate of speech (post-treatment)
S242 = Attitude toward stuttering (post-treatment)
NAT2 = Naturalness rating (post-treatment)
DYP = Dynamometer (preferred hand score)
DYNP = Dynamometer (non-preferred hand score)
DY = Dynamometer (laterality measure)
FTP = Finger tapping test (preferred hand score)
FTNP = Finger tapping test (non-preferred hand score)
FT = Finger tapping test (laterality measure)
PPP = Purdue pegboard (preferred hand score)
PPNP = Purdue pegboard (non-preferred hand score)
PPB = Purdue pegboard (both hand score)
PPA = Purdue pegboard (assembly score)
PP = Purdue pegboard (laterality measure)
TR A = Trailmaking test (version A - time score)
TR B = Trailmaking test (version B - time score)
TPP = Tactual performance test (preferred hand - time score)
TPNP = Tactual performance test (non-preferred hand - time score)
TPB = Tactual performance test (both hands - time score)
TPM = Tactual performance test (memory score)
TPL = Tactual performance test (localization score)
TP = Tactual performance test (laterality measure)
HCT = Halstead category test (error score)
WISC = Wisconsin card sorting test (error score)
SG = Symbol gestalt (derived error score)
SDO = Symbol-digit modalities test (oral version)
SDW = Symbol-digit modalities test (written version)
SD = Symbol-digit modalities test (verbal/nonverbal measure)
OWF = Word fluency test (oral version)
WWF = Word fluency test (written version)
WF = Word fluency test (verbal/nonverbal measure)
VIQ = Verbal intelligence quotient
PIQ = Performance intelligence quotient
FSIQ = Full scale intelligence quotient
IQ = Intelligence quotient (verbal/nonverbal measure)
%SS1 = Average frequency of stuttering (pre-treatment)
SPM1 = Average rate of speech (pre-treatment)
S241 = Attitude toward stuttering (pre-treatment)
NAT1 = Naturalness rating (pre-treatment)

Section 5 discusses a recalculated coefficient of multiple determination (R^2) that may be a more probable population value for each regression analysis. Implications of these results are discussed in Chapter Five.

DESCRIPTIVE STATISTICS

The means, standard deviations (SD) , medians and skewness for each of the criterion variables are given in Table IV. Low reliability for the naturalness ratings (p. 64), contraindicated regression analysis with naturalness as the criterion variable. Therefore NAT2 was excluded.

TABLE IV

DESCRIPTIVE STATISTICS FOR THE CRITERION VARIABLES

Variable	Mean	Median	SD	Skewness
%SS2	1.1290	.37	1.779	1.879
SPM2	155.8860	175.90	43.306	- .437
S242	9.7330	9.00	5.298	.354
NAT2	3.1560	2.33	2.270	.990

Note: S242 was calculated based on 15 subjects as 2 subjects were below administration age.

From the descriptive statistics, evidence of extreme positive skewness in the distribution of %SS2 was found. Although undesirable, a basement effect for the clinical scores was to be expected. Subjects who were successful in therapy could not achieve greater than 0% stuttering post-treatment.

Descriptive statistics for predictor variables in this study are presented in Table V. NAT1 was excluded due to its low reliability (p. 64).

TABLE V

DESCRIPTIVE STATISTICS FOR THE PREDICTOR VARIABLES

Variable	Mean	Median	SD	Skewness
DYP	43.140	46.50	12.914	- .973
DYNP	39.171	40.90	11.754	- .743
DY	4.029	3.50	4.873	.043
FTP	47.094	48.80	7.129	- .155
FTNP	43.212	43.40	6.357	- .572
FT	6.788	6.60	8.26	.315
PPP	14.471	14.00	2.125	- .039
PPNP	13.882	13.00	1.933	.653
PPB	11.529	12.00	1.772	- .363
PPA	35.353	38.00	5.195	- .470
PP	.588	0.00	1.698	.279
TR A	23.366	19.50	10.567	.762
TR B	63.895	56.00	37.174	1.574
TPP	350.441	292.80	153.017	1.138
TPNP	307.476	248.80	157.050	1.098
TPB	198.959	159.00	162.124	2.143
TPM	6.588	8.00	3.063	- .862
TPL	4.412	4.00	2.002	- .252
TP	42.988	-44.20	93.672	.54
HCT	45.824	36.00	34.089	1.386
WISC	23.118	16.00	19.248	.634
SG	.361	.354	.285	.495
SDO	52.647	54.00	13.430	- .856
SDW	55.176	52.00	14.479	1.433
SD	-2.529	- 2.00	14.027	- .504
OWF	12.613	11.67	4.377	.231
WWF	10.796	10.20	3.672	.580
WF	1.758	1.66	2.757	.382
VIQ	109.941	111.00	16.150	- .412
PIQ	110.647	105.00	18.755	.181
FSIQ	110.941	111.00	18.376	- .015
IQ	-.706	2.00	10.815	- .344
%SS1	14.017	10.53	13.815	1.551
SPM1	135.128	127.06	46.203	- .437
S241	17.214	20.00	5.28	- .818
NAT1	3.413	3.67	1.487	.558

Note: S241 was based on 14 subjects as 1 subject failed to complete the form and 2 subjects were below administration age.

In summary, multiple regression analyses were computed to predict the criterion variables: %SS2, SPM2, and S242. For each regression analysis the predictor variables were as follows: DYP, DYNP, DY, FTP, FTNP, FT, PPP, PPNP, PPB, PPA, PP, TR A, TR B, TPP, TPNP, TPB, TPM, TPL, TP, HCT, WISC, SG, SDO, SDW, SD, OWF, WWF, WF, VIQ, PIQ, FSIQ, IQ, %SS1, SPM1, and S241.

REGRESSION ANALYSES

A series of three regression analyses were computed to predict post-treatment clinical speech measures based on pre-treatment neuropsychological and clinical speech measures. Since this was an exploratory study of the problem, *F* = 3.0 was selected for variable entry into the regression equation and *F* = 2.99 was employed for variable removal. Although this small *F* reduces generalization, it still represents an acceptable level of significance as *F* = 4.0 and 3.99 constitute the default entry and removal criteria utilized by Statview 512+.

In a multiple regression analysis, the number of predictor variables that can be examined for entry into the regression equation at one time is determined by 'n-1', where 'n' = number of cases. In this study there were 17 subjects, therefore, a maximum of 16 predictor variables (and one criterion variable) could be analyzed at one time. Since no basis for selection or grouping of predictor variables was made clear by a search of the literature, all predictor variables were analyzed. The 36 predictor variables were analyzed in three groups: the first 16 predictors constituted one group, the next 16 constituted a second group, and the final 4 predictors constituted a third group. Variables

used in determination of the three regression equations (as selected by the computer based on their partial correlations) were recorded. These computer-selected variables were then combined for use in an analysis which determined the final regression equation. This same procedure was utilized in the computation of each regression equation.

The tables below present results of three stepwise multiple regressions. A summary table presents: the predictor variable entered for each step of the analysis, the multiple correlation (R) of the predictor variables entered on that step, the squared multiple correlation showing the amount of variance explained by the predictor variables to that point, and an analysis of variance table containing the *F* statistic associated with stepwise change in R^2. The analysis of variance table for the final step in each regression is succeeded by a second table providing the individual beta values for the regression equation and the intercept value. Findings are presented separately for each of the criterion variables. Table VI provides the regression results for the criterion variable, %SS2. Tables VII and VIII serve the same purpose for the criterion variables, SPM2 and S242, consecutively. A discussion of the findings follows each table.

TABLE VI

STEPWISE MULTIPLE REGRESSION FOR CRITERION VARIABLE - %SS2

Step No. 1: Variable X1 entered - TPL

Multiple R: .619 R squared: .383

Analysis of Variance Table

Source	DF	SS	MS	F	P
REGRESSION	1	19.375	19.375	9.303	< 0.01
RESIDUAL	15	31.238	2.083		
TOTAL	16	50.613			

TABLE VI - CONTINUED

Step No. 2: Variable X_2 entered - DYP

Multiple R: .729 R squared: .532

Analysis of Variance Table

Source	DF	SS	MS	F	P
REGRESSION	2	26.927	13.463	7.958	< 0.01
RESIDUAL	14	23.686	1.692		
TOTAL	16	50.613			

Step No. 3: Variable X_3 entered - SG

Multiple R: .79 R squared: .624

Analysis of Variance Table

Source	DF	SS	MS	F	P
REGRESSION	3	31.583	10.528	7.192	< 0.005
RESIDUAL	13	19.03	1.464		
TOTAL	16	50.613			

Step No. 4: Variable X_4 entered - TR A

Multiple R: .837 R squared: .7

Analysis of Variance Table

Source	DF	SS	MS	F	P
REGRESSION	4	35.45	8.862	7.014	< 0.005
RESIDUAL	12	15.163	1.264		
TOTAL	16	50.613			

VARIABLES IN THE %SS2 EQUATION

Parameter	Value	Std. Err.	F
INTERCEPT	4.48		
TPL	- .788	.16	24.335
DYP	.063	.023	7.781
SG	-3.277	1.266	6.707
TR A	- .061	.035	3.06

A multiple regression analysis showed that approximately 70.00%

of the variance in post-treatment frequency of stuttering, for this sample, could be accounted for by the equation:

$$\%SS2 = 4.48 + TPL\ (-.788) + DYP\ (.063) + SG\ (-3.277) + TR\ A\ (-.061)$$

The unique contribution of each of the four predictors is difficult to determine as the explained variance in %SS2 was accounted for by the four predictor variables jointly. It should be noted that each predictor variable reached the alpha level of .01 for inclusion, indicating that the increase in goodness of fit was 'statistically significant'.

One predictor variable, TPL, showed a greater significance than the remaining three. Although its beta weighting in the equation was only -.788 as opposed to -3.277 for SG, its' *F*-to-enter value was 9.03. This appeared to be a variable with moderate significance and indicated that it may prove valuable as a predictor in future regression studies with stutterers.

Goodness of fit for the regression equation was evaluated using the *F* value of 7.014 ($p<0.005$), indicating that the relationship between the criterion and predictor variables was significant. Goodness of fit was increased by the reduction of the *F*-to-enter to 1.0. With the lower *F*, 89.2% of the variance in %SS2 was predicted by the regression equation:

$$\%SS2 = 10.86 + TPL\ (-.668) + DYP\ (.107) + SG\ (-1.72) + PPA\ (-.205)$$
$$+ WISC\ (-.058) + SDW\ (-.035) + DY\ (-.073) + IQ\ (-.031)$$

Although this equation had superior predictive value for this sample, its generalization to the population is far more restricted. The lower *F* allowed the inclusion of predictors that may be idiosyncratic to this sample and thus their value in future research is questionable.

TABLE VII

STEPWISE MULTIPLE REGRESSION FOR CRITERION VARIABLE - SPM2

Step No. 1: Variable X_1 entered - SDO

Multiple R: .782 R squared: .612

Analysis of Variance Table

Source	DF	SS	MS	F	P
REGRESSION	1	17153.47	17153.47	23.638	0.000
RESIDUAL	15	10885.21	725.681		
TOTAL	16	28038.68			

Step No. 2: Variable X_2 entered - TPP

Multiple R: .887 R squared: .787

Analysis of Variance Table

Source	DF	SS	MS	F	P
REGRESSION	2	22056.058	11028.029	25.807	0.000
RESIDUAL	14	5982.622	427.33		
TOTAL	16	28038.68			

VARIABLES IN THE SPM2 EQUATION

Parameter	Value	Std. Err.	F
INTERCEPT	114.998		
SDO	1.75	.435	16.162
TPP	-.129	.038	11.162

A multiple regression analysis showed that approximately 78.70% of the variance in post-treatment rate of speech, for this sample, could be accounted for by the equation:

$$SPM2 = 114.998 + SDO\ (1.75) + TPP\ (-.129)$$

The multiple regression equation showed strong dependence ($R^2 = .787$) on two predictor variables. Goodness of fit for the regression equation was evaluated using the *F* value of 25.807 ($p=0.00$).

The unique contribution of each of the predictors is difficult to determine as the explained variance in SPM2 was accounted for by the two predictor variables jointly. It should be noted that both predictor variables reached the alpha level of .01 for inclusion, indicating that the increase in goodness of fit was 'statistically significant'. Both predictor variables showed good significance, with *F* values significantly large that they would pass an *F* -to-enter value of 4.0. This means that SDO and TPP account for 78.70% of the variance in post-treatment rate of speech (SDO, alone, accounted for 61.20% of the variance) and the probability of the relationship being due to chance was 0.00%. Thus, these variables may prove valuable as predictors in future regression studies with stutterers.

On the average, 21.30% of the variance was not be explained by the predictor scores. However, this remaining variance was greatly reduced when the *F* -to-enter was decreased to 1.0. With the lower *F* , 93.9% of the variance in SPM2 was predicted by the regression equation:

$$\text{SPM2} = 151.684 + \text{SDO}\,(1.496) + \text{TPP}\,(-.104) + \text{TR B}\,(-.698) +$$
$$\text{TR A}\,(1.523) + \text{TPP}\,(-.075) + \text{FTNP}\,(2.598) + \text{PP}\,(-5.769)$$

As with the new regression equation created for %SS2, this equation had superior predictive value for this sample, but restricted generalization to the population.

TABLE VIII

STEPWISE MULTIPLE REGRESSION FOR CRITERION VARIABLE - S242

Step No. 1: Variable X_1 entered - SPM1

Multiple R: .842 R squared: .71

Analysis of Variance Table

Source	DF	SS	MS	F	P
REGRESSION	1	278.839	278.839	31.771	0.000
RESIDUAL	13	114.094	8.776		
TOTAL	14	392.933			

Step No. 2: Variable X_2 entered - PP

Multiple R: .891 R squared: .794

Analysis of Variance Table

Source	DF	SS	MS	F	P
REGRESSION	2	311.853	155.926	23.077	0.000
RESIDUAL	12	81.081	6.757		
TOTAL	14	392.933			

Step No. 3: Variable X_3entered - OWF

Multiple R: .929 R squared: .863

Analysis of Variance Table

Source	DF	SS	MS	F	P
REGRESSION	3	339.067	113.022	23.08	0.000
RESIDUAL	11	53.866	4.897		
TOTAL	14	392.933			

Step No. 4: Variable X_4 entered - %SS1

Multiple R: .952 R squared: .907

Analysis of Variance Table

Source	DF	SS	MS	F	P
REGRESSION	4	356.235	89.059	24.268	0.000
RESIDUAL	10	36.698	3.67		
TOTAL	14	392.933			

VARIABLES IN THE S242 EQUATION

Parameter	Value	Std. Err.	F
INTERCEPT	34.144		
SPM	-.121	.024	24.657
PP	.735	.296	6.169
OWF	-.448	.144	9.748
%SS1	-.182	.084	4.678

A multiple regression analysis showed that approximately 90.70% of the variance in post-treatment attitude towards speech, for this sample, could be accounted for by the equation:

S242 = 34.144 + SPM1 (-.182) + PP (.735) + OWF (-.448) + %SS1 (-.182)

The multiple regression equation showed strong dependence (R^2 = .907) on four predictor variables. Goodness of fit for the regression equation was evaluated using the *F* value of 24.268 (p=0.00).

The unique contribution of each of the predictors is difficult to determine as the explained variance in S242 was accounted for by the four predictor variables jointly. Again, it should be noted that each predictor variable reached the alpha level of .01 for inclusion, indicating that the increase in goodness of fit was 'statistically significant'. All four predictor variables showed good significance, with *F* values significantly large that they would pass an *F* -to-enter value of 4.0. Of particularly high significance was SPM1 (*F* -to-enter = 31.771, p=0.00). It, alone, accounts for 71.00% of the variance in post-treatment attitude towards speedch. Thus, this variable may prove valuable as a predictor in future regression studies with stutterers.

On the average, 9.30% of the variance was not be explained by the predictor score. Again, this remaining variance was greatly reduced when the *F* -to-enter was decreased to 1.0. With the lower *F* , 93.80% of the variance in SPM2 was predicted by the equation:

$$\begin{gathered} S242 = 51.349 + SPM1\ (-.117) + OWF + (-.695) + \%SS1\ (-.329) + \\ SDW\ (-.171) + DY\ (-.296) + WISC\ (-.045) \end{gathered}$$

Similar to the effect seen for the new %SS2 and SPM2 regression equations, this improved the predictive value of the equation for this sample, however, restricted its generalization to the population.

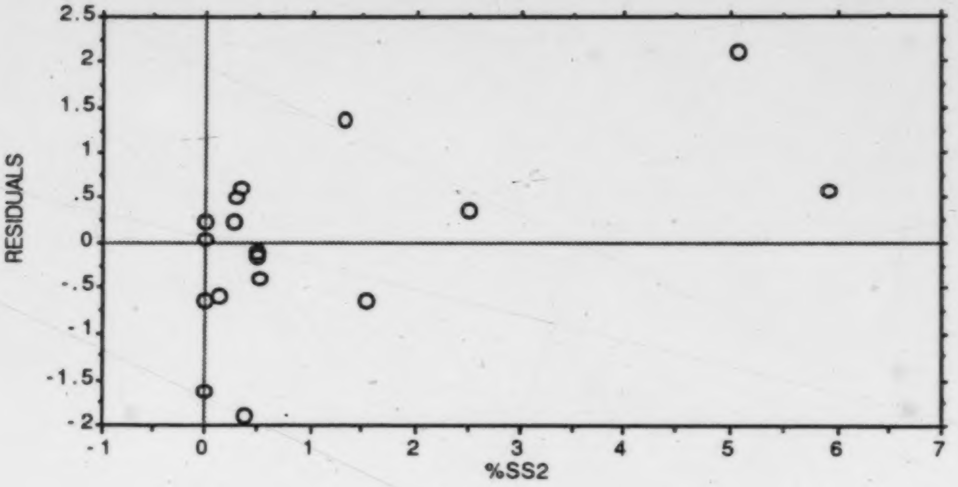
POST-FITTING CHECKS

It was recommended by several authors (Cooper & Weekes, 1983; Hamburg, 1983; Norusis, 1982) that investigators who utilize multiple regression analyses examine the residuals created by derivation of the regression equation. Residuals from the three regression analyses are graphically presented in Figures II, III and IV. These graphs were plotted with the criterion variable on the X-axis and residual errors on the y-axis, so that the data points could be examined for positive and negative excursion around the origin. The graphs were examined for evidence of nonlinearity, heteroskedasticity (lack of a constant variance in the residual error terms), and outliers.

In Figure II , evidence of heteroskedasticity and outliers can be seen. The statistical cost of heteroskedasticity is increased standard error of the regression coefficients, while the result of outliers may be a poorly fitted model (Cooper & Weekes, 1983). These findings will be discussed at length in Chapter Five.

FIGURE II

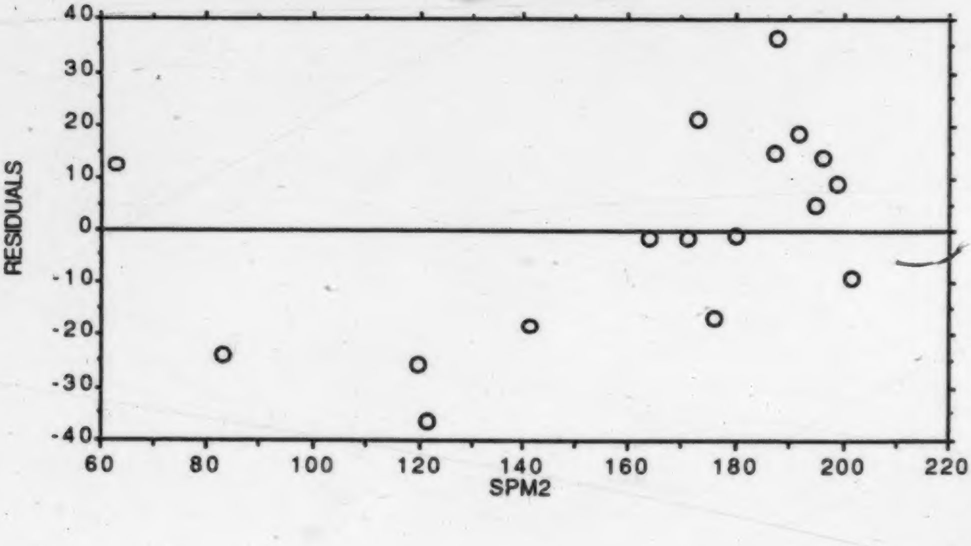
SCATTERGRAM FOR RESIDUAL ERROR OF %SS REGRESSION ANALYSIS



In Figure III , evidence of heteroskedasticity and outliers can be seen. These findings will also be discussed in Chapter Five.

FIGURE III

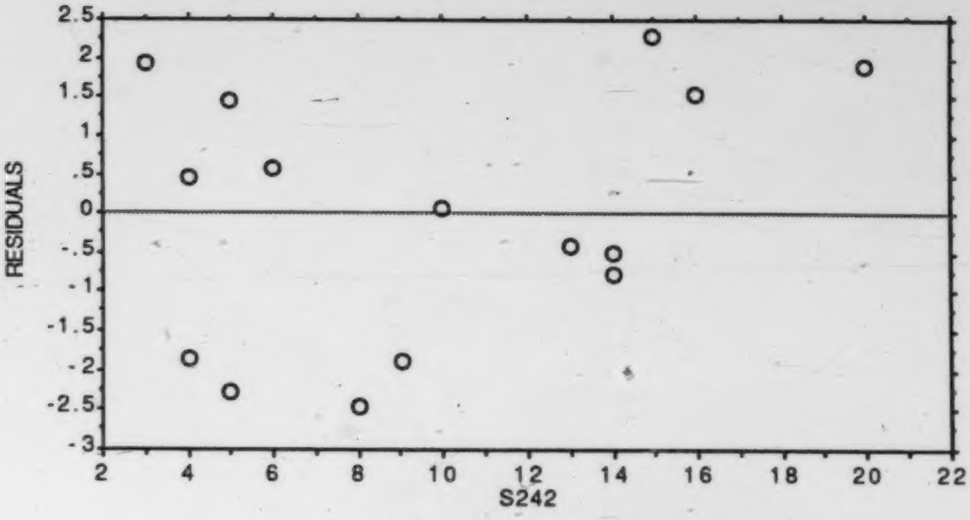
SCATTERGRAM FOR RESIDUAL ERROR OF SPM REGRESSION ANALYSIS



In Figure IV , evidence of extreme heteroskedasticity was found. Implications will be discussed in Chapter Five.

FIGURE IV

SCATTERGRAM FOR RESIDUAL ERROR OF S24 REGRESSION ANALYSIS



CORRELATION MATRICES

A second means of checking the precison of regression equations is to calculate correlation matrices. The matrices will show: (1) correlations between criterion variables and predictor variables and (2) intercorrelations between predictors variables in each regression equation (Norusis, 1982). In this manner, they permit a check for multicollinearity (Pg. 75), a problem which can reduce the precision of estimates made by the regression equation. Findings are presented for the variables in each regression equation separately. Table IX provides the correlation matrix for variables in the %SS2 regression equation. Tables X and XI serve the same purpose for variables of the SPM2 and S242 regression equations, respectively. A discussion of the results follows each table.

TABLE IX

CORRELATION MATRIX OF VARIABLES IN %SS2 REGRESSION EQUATION

	%SS	TPL	DYP	SG	TR A
%SS	1				
TPL	- .619	1			
DYP	.231	.234	1		
SG	- .192	-.145	.011	1	
TR A	.153	-.231	.045	-.551	1

From Table IX, it is apparent that multicollinearity may be a problem. Although none of the intercorrelations were high, the correlation between DYP and SG was close to 0 and thus may indicate near-singularity. For this reason, the precision of the estimates may be low and interpretation of results must be guarded. It was also noted that the predictor, TR A, may have been acting as a suppressor variable for SG.

TABLE X

CORRELATION MATRIX OF VARIABLES IN SPM REGRESSION EQUATION

	SPM2	SDO	TPP
SPM2	1		
SDO	.782	1	
TPP	-.735	-.467	

From Table X, it was apparent that the correlation between the criterion and the predictors was high.

TABLE XI

CORRELATION MATRIX OF VARIABLES IN S242 REGRESSION EQUATION

	S242	SPM1	PP	OWF	%SS1
S242	1				
SPM1	- .842	1			
PP	.176	.132	1		
OWF	-.7	.555	.023	1	
%SS1	.68	-.902	-.175	-.573	1

Data in Table VIII evidenced both a suppressor variable, %SS1, and multicollinearity. Multicollinearity is suspected whenever intercorrelations are relatively high. Most intercorrelations for these predictor variables were moderate (SPM1 with OWF, OWF with %SS1) to extremely high (SPM1 with %SS1). Therefore, multicollinearity was assumed, and precision of the estimates was considered to be questionnable. Re-examination of heteroskedasticity present in the residual error scatterplot (Figure IV) was interpreted as confirmation of low precision of the estimates for the regression equation. As recommended by Hamburg (1983) and Parson (1978), one of the predictor variables was deleted in order to reduce the degree of multicollinearity. With the exclusion of %SS1 from the regression equation, the amount of variance explained by the equation was reduced along with the degree of multicollinearity. Surprisingly, however, the amount of heteroskedasticity in the residual errors increased. It was the investigator's decision that %SS1 should be included in the regression analysis and results should be interpreted with extreme caution.

SHRINKAGE IN 'R'

A final consideration in the interpretation of regression results is the amount of generalization possible with the derived regression equation. A bias in the results occurs because, in calculating of the 'equation with the best possible fit', the beta weights capitalize on idiosyncrasies within the sample and chance deviations in the correlation coefficients. This results in an inflated value for 'R', with the degree of bias increasing with increases in the number of predictor variables and decreases in the sample size (Ferguson, 1976).

The formula used in this study, to'shrink' R to a more probable value for the population was given on page 76. Results of the recalculation of R are given in Table XII, along with corresponding changes in R^2.

TABLE XII

RECALCULATIONS OF R AND R^2

	Sample	Sample R	Population R^2	Population R^2
%SS Regression Analysis	.837	.700	.794	.631
SPM Regression Analysis	.887	.787	.879	.773
S24 Regression Analysis	.952	.907	.941	.886

Results from Table XII indicated that little predictive value was lost when extrapolating the results of this study to the population. These results may have been due, in part, to the high *F* values achieved by the predictor values in the original regression analyses. As well, the small number of predictor variables utilized in the equations also reduced the amount of shrinkage. Further discussion regarding the significance of these results can be found in Chapter Five.

CHAPTER FIVE: DISCUSSION

In this study, an attempt was made to find variables, or sets of variables, that would serve as good predictors of success in therapy. Based on research regarding stuttering and hemispheric processing, it was hypothesized that neuropsychological variables in combination with clinical speech measures might perform this function, as attempts to predict therapy outcome utilizing clinical measures alone have been unsuccessful. While no studies combining predictors from the fields of speech pathology and neuropsychology have been reported, the investigator felt that the possibility of a relationship existed.

A study was designed to determine the predictive value of four clinical speech measures (four variables) and 13 neuropsychological measures (32 variables), administered to 17 male stutterers prior to an intensive three-week treatment program. These 17 pretreatment measures resulted in 36 predictor variables. These variables were then used to predict the four clinical speech measures (post-treatment frequency of stuttering, rate of speech, attitude towards speech and speech naturalness rating) which were readministered after therapy.

MAJOR FINDINGS

Results indicated that four of the 32 neuropsychological variables (TPL, DYP, SG, and TR A) operated as level of performance estimators for post-treatment frequency of stuttering. In other words, these variables were the best predictors of post-treatment frequency of stuttering. This finding supplements the work of Guitar (1976). With a multiple regression analysis, he was able to predict subjects' post-treatment outcome (%SS) using a measure of personality (Eysenck Personality Inventory), two measures of attitudes about stuttering (Modified S24 Scale and Stutterer's Self-Ratings form), and a measure of the amount of stuttering (%SS). Guitar reported that pretreatment attitude was the best predictor of treatment outcome. In the current study, both neuropsychological variables and the S-24 scale, an attitudinal measure, were used. Only the neuropsychological variables were found to be predictors of outcome. However, this should not be construed as contradicting the results of Guitar as the population and adopted significance levels may have differed. Since there are no previous reports in the literature which suggest that neuropsychological variables may be predictors of treatment outcome in stuttering therapy, this finding is unique and of major significance.

In addition to frequency of stuttering, another important measure of severity is speech rate , as measured by SPM. The frequency of stuttering varies inversely with the syllable rate so that as the frequency of stuttering decreases, the rate of speech increases. Normal syllable rate in adult conversation is considered to be 190 ± 20 SPM (Boberg & Kully, 1985). Two neuropsychological variable, SDO and TPP, were identified as the best predictors of post-treatment rate of speech. Again, the best predictors were neuropsychological measures, a unique finding, as no other studies of this relationship have been reported.

It is interesting to note that the six strongest predictors of post-treatment severity, as measured by %SS and SPM, were neuropsychological measures. This indicates the possibility of brain dysfunction, as measured by neuropsychological testing, as a factor in stuttering. It suggests that further attention should be paid to the contribution of brain function in the onset and treatment of stuttering. Until the relationship between prediction of therapy outcome and specific neuropsychological measures has been clarified by additional studies, it would be unwise to draw firm conclusions from the relationships reported in this investigation.

Another important clinical measure is the client's attitude towards his own speech. The results of this study indicated that post-treatment attitude, measured with the S24 scale, was predicted best by the two pretreatment clinical speech measures, %SS and SPM, and two neuropsychological measures, PP and OWF. The S24 attitude scale was used previously by Guitar (1976), Guitar and Bass (1978), and Helps and Dalton (1979) as a predictor of therapy outcome. Findings of the current study generally support the results of these investigators, that 'attitude toward speech, as measured by the S24, is related to stuttering severity'; however, this investigator took the relationship one step further, by using the S24 scale, not only as a predictor variable, but a criterion variable as well. The relationship between attitudes and severity was tested in two directions: (1) whether pre-treatment attitude towards speech (measured using the S24 attitude scale) could predict post-treatment severity (using the %SS and SPM) and (2) whether pre-treatment severity could predict post-treatment attitude towards speech. Findings supported the relationship stated in (2) above, however, there was no evidence to support the first relationship. In other words, pre-treatment attitude towards speech was not a predictor of post-treatment frequency of stuttering or rate of speech. Yet, pre-treatment frequency of stuttering and rate of speech were good predictors of post-treatment attitude towards speech.

The final clinical measure, speech naturalness ratings, did not reveal clinically useful results. The naturalness ratings were gathered in accordance with the procedure outlined by Martin, Haroldson, and Triden (1984). Interjudge reliability was found to be low and inconsistent, ranging from r= .257 to r= .724, with intrajudge reliability ranging from r= -.850 to r= .988 (Table II). These figures are in sharp contrast to the high interjudge reliability (ranging from r= .74 to r= .98) reported by Martin et al. (1984). While the reasons for these differences are not clear, the interjudge reliability discrepancies may be partially explained by the different means used to calculate interjudge reliability. In their study, Martin et al. (1984) used an interclass correlation procedure, whereas in the present study a paired point-to-point correlation procedure was used, the values of each judge being checked against those of every other judge (ie. Judge A with B, Judge A with C, and Judge B with C). The rigorous reliability check used in this study, precluded use of speech naturalness ratings. Further research is required to determine the nature of the discrepancies between the reliability reported by the current investigator and that of Martin et al. (1984) and the usefulness of the naturalness measure as both a predictor and criterion variable.

IMPLICATIONS

In view of the relationship demonstrated in this study between pre-treatment neuropsychological measures and post-treatment stuttering behavior, one would expect heightened interest in neuropsychological models of stuttering, such as that proposed by

Yeudall (1985).

In addition to theoretical implications of these findings, there are also clinical implications. Results have suggested the possibility of developing a new assessment tool for stuttering. There are numerous difficulties in predicting outcome of stuttering therapy. This study has demonstrated that neuropsychological variables can be useful for predicting outcome. While eight neuropsychological predictors (TPL, DYP, SG, TR A, SDO, TPP, PP, and OWF) have been revealed to have predictive value, still others may exist. An additional bonus of using neuropsychological measures as assessment variables is that they provide a more objective measure than some of the clinical measures typically used by speech-language pathologists. Thus, while replication and further testing is needed, this study may provide the first step in the development of an objective, comprehensive test battery which may be useful, in collaboration with general speech measures, in prediction of therapy outcome.

ADDITIONAL FINDINGS

Many authors have cited the possibility of subgroups within the stuttering population as an explanation of the stutterer's response to therapy (Beech & Fransella, 1968; Hayhow, 1983). There are, at the moment, no reports in the literature on the characteristics of stutterers which suggest a logical and objective system for dividing stutterers into subgroups. Results from this study suggest a procedure by which this goal may be achieved.

In the process of attempting to verify the linear regression model assumption of homogeneity, that being the assumption that all subjects are from the same population, it became apparent that certain subjects did not belong with the remainder of the group. This was evident in their failure to cluster with the remaining scores. The raw data (Appendix J) were examined and univariate scattergrams were plotted for each predictor variable. Three subjects were excluded from the plots as they were under 15 years of age and therefore constituted a separate neuropsychological population. Scattergrams displayed raw scores as they distributed in relation to the mean for each variable. This allowed the investigator to inspect each variable separately for evidence of outliers or scores that fell beyond one standard deviation from the mean of the group. Three subjects were thus identified, who did not appear to belong to the same population as the remaining subjects. These outliers were subjects 3, 10, and 13. Neuropsychological profiles for these subjects are presented in Appendix K.

Subjects 3 and 13 both evidenced a myriad of extreme deviations in neuropsychological and clinical speech scores. Subject 10 demonstrated numerous neuropsychological deficits and mild to moderate abberations in clinical speech measures. The deviations exhibited by these three subjects suggest the possibility of subgroups within the population of stutterers.

In order to verify the uniqueness of the three clients identifed as outliers by neuropsychological and clinical speech assessment measures, a review of their clinical files was conducted. All three subjects were noted to have experienced unusual difficulties in the treatment program. For example, in the early stages of treatment, when specific fluency skills are taught, these three subjects had difficulty gaining proficiency with the skills due to excessive, uncontrollable tension. Moreover, all three subjects failed to reach the final target of normal speech rate, even within the clinic setting. The speech pathologist who worked with the three subjects confirmed that, they were unable to complete the program within the normal three-week period and that they had made minimal progress in therapy. It is of further interest that the speech pathologist also observed evidence of significantly inappropriate social behavior in two of the three subjects. Additional evidence of the uniqueness of the outliers is available for two of the subjects. Samples of their speech collected during the maintenance period (following the completion of therapy) revealed that these subjects had suffered serious relapses. In other words, the three subjects who were identified as outliers by the pre-treatment neuropsychological procedures, were also unique within the clinical program by their failure to complete the program and their inability to maintain, in the post-treatment period, even those minimal gains they had achieved in therapy.

These findings are of considerable interest for both theoretical and clinical reasons. They seem to reinforce the notion that stutterers are not a homogeneous population. If this is supported by further studies, the existence of subgroups with different characteristics must be taken into account in the development of etiological theories and models, as well as in the design of research.

The possible existence of subgroups within the stuttering population has several clinical implications. One likely possibility is that treatment strategies that are effective with one group may not be effective for another group. Treatment programs will need to be planned with due reagard to the needs of individuals within each subgroup. Another possibility is that stutterers from different subgroups will differ substantially in their ability to maintain clinical gains. This was suggested by Boberg and Yeudall (1984), when they observed that the two subjects who had great difficulty maintaining their clinical gains also evidenced extreme deficits in their neuropsychological profiles. The correlate of this was that two successful cases, demonstrated relatively intact neuropsychological systems, made substantial gains in therapy and were maintaining these gains five years post-treatment.

LIMITATIONS

The theoretical implications, clinical implications, and generality of the findings must be considered in view of the limitations of this study. A research model was adopted which would allow the handling of the large number of variables and which would give maximum power to the findings. Under strict interpretation, all conditions of the design were not fulfilled indicating that caution must be used in generalizing the findings from this study.

One obvious limitation in the present study was the sample size. Ideally, this design should have 30 or more subjects, however, only 17 were obtained. Although this N is smaller than the design called for, it is well within the range of the average study in the area of stuttering. More than 50% of the published studies on treatment outcome summarized in a recent review, reported an N of less than 20 (Bloodstein, 1987).

Secondly, because a large number of variables were included in this study, 'data snooping' procedures were used. 'Data snooping' was present in the grouping of the variables for inclusion in the regression analysis, as grouping was not possible on a logical basis. The results of an initial grouping were examined for evidence of promising predictors, and further groupings were based on these findings. Although, this is not standard procedure, due to the lack of previous investigation of the relationships examined in this study, this procedure appeared warranted.

Finally, although the research design called for a random sample, this was not possible because there was a limited number of subjects available. Only volunteer subjects enrolled for therapy at the Institute for Stuttering Treatment and Research were available. Thus results are generalizable only to volunteer subjects enrolled in a similar stuttering treatment program.

SUMMARY OF FINDINGS

This study set out to investigate which clinical and/or neuropsychological variable, or combination of variables, serves as the best predictor of a stutterer's response to stuttering therapy, as determined by post-treatment clinical measures. With due regard to the limitations described above, the following tentative conclusions were reached:

1. Four neuropsychological measures, administered pre-treatment, were found to predict post-treatment frequency of stuttering.
2. Two neuropsychological measures, administered pre-treatment, were found to predict post-treatment rate of speech.
3. Two clinical speech and two neuropsychological measures,

administered pre-treatment, were found to predict post-treatment attitude towards speech.

4. Since the best predictors of post-treatment stuttering severity were neuropsychological measures, it appears reasonable that neuropsychological factors should be included in any consideration of the development of theoretical models and the treatment of stuttering.
5. Three of the 17 subjects showed such a distinctive neuropsychological performance profile that they could legitimately constitute one or more specific subgroups, the existence of which may lead to changes in treatment approaches.
6. The neuropsychological measures, demonstrated to have predictive power, may constitute the first step in the development of a general test battery to aid the speech pathologist in assessing and planning treatment for stuttering clients.

RECOMMENDATIONS FOR FUTURE RESEARCH

Several recommendations can be made regarding further studies of neuropsychological aspects of stuttering:

1. A similar study, with a larger N, is needed to determine if the results obtained in this investigation can be replicated.
2. Another study should extend the time-line of the measures to include long-term clinical outcome measures. Results from such a study might increase the accuracy in predicting long-term clinical gains.
3. As this exploratory study revealed eight possible neuropsychological predictor variables of treatment outcome,

it would be important to consider additional neuropsychological measures to determine if still other measures might serve as useful predictors.

4. Consideration should be given to the possibility of subgroups within a sample of stutterers. The identification of one or more subgroups within this study was serendipitous and requires further investigation. Attention could be directed toward the development of a means of characterizing or otherwise identifying those stutterers who might constitute a subgroup.

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APPENDIX A

ISTAR TREATMENT APPROACH

The treatment program utilized at ISTAR is described extensively in Boberg and Kully (1985). In this discussion, only the main elements of therapy will be outlined.

The Boberg-Kully Comprehensive Stuttering Program (Boberg & Kully, 1985) is an eclectic treatment approach. It uses primarily a behavioral approach to alter speech performance, however, it also gives attention to the shaping of a positive attitude.

The program is arranged in seven phases. Each phase has its own purpose, objectives, and set of treatment steps. The program may be outlined as follows:

Phase I - Group Orientation

The puposes are to:

a) introduce the clients to the dimensions of the program, and

b) prepare clients for their responsibilities in the 3-week clinic.

The steps include:

1. Information for clients
2. Speech measurement
3. Explanation of the measurement system, calculation of rate and stuttering scores

Phase II - Identification

The purposes are to:

a) develop awareness of stuttering, and

b) teach clients to identify and describe stuttering behavior.

The steps include:

1. Information for clients
2. Cooperative identification and description using audio tapes
3. Self-identification and description using audio tapes
4. Identification of stuttered episodes while speaking

Phase III - Early Modification

The purposes are to:

a) develop a rudimentary understanding of speech production processes, and

b) introduce the fluency skills (soft phrase onsets, soft contacts, blending, and phrasing).

The steps include:

1. Information for clients
2. Explanation of speech production processes
3. Preliminary relaxation exercises
4. Vowels in isolation
5. Consonant-vowel combinations
6. Mono- and polysyllabic words
7. Phrases and sentences

Phase IV - Prolongation

The purpose is to develop prolonged speech at 60 ± 20 spm, while using the fluency skills. The steps include:

1. Information for clients
2. Prolongation at 60 spm
    - i. Develop sustained prolongation at 60 spm
    - ii. Develop short phrases of 2 - 6 syllables
    - iii. Soft phrase onsets
    - iv. Soft contacts
    - v. Continuous airflow / blending
3. Self-assessment test

Phase V - Rate Increase and Cancellation / Self-correction

The purposes are to:

a) gradually increase the rate of speech to develop normal-sounding fluent speech,
b) develop self-correction and rate change skills,
c) develop appropriate eye contact, and
d) facilitate development of appropriate attitudes.

The steps include:

1. Prolongation at 90 ± 20 spm
2. Prolongation at 120 ± 20 spm
3. Prolongation at 150 ± 20 spm
4. Prolongation at 190 ± 20 spm

Phase VI - Self-monitoring and Transfer Training

The purposes are to:

a) develop self-monitoring skills at normal speaking rates, and
b) develop further rate change skills.

The steps include:

1. Self-monitoring sessions
2. Rate changes
   i. Therapist-directed rate changes
   ii. Self-directed rate changes

Phase VII - Transfer

The puposes are to:

a) transfer normal-sounding fluent speech to non-clinical settings,

b) further develop self-analysis skills.

The steps include:

1. Information for clients
2. Transfer assignments
   i. Standard assignments
   ii. Personalized assignments

Following completion of the seven phases of the program, clients are aided in drafting a personal maintenance plan. This plan is designed to facilitate long-term maintenance of the therapy gains, in the post-treatment environment.

The Boberg-Kully Comprehensive Stuttering Program follows a standard format and has been used successfully with over 500 clients. Administration is highly standardized and the program has been utilized in the training of 40 - 50 student speech pathologists. Thus, while minor differences exist in the administration of the program with each client group, therapist and response variables are minimized.

APPENDIX B

LETTER REQUESTING PARTICIPATION

Department of Speech Pathology and Audiology
University of Alberta

Dear Mr.

I have been given the authority to conduct stuttering research with the Institute for Stuttering Treatment and Research (ISTAR) and request permission to include you in my thesis study. My study is looking at stuttering and various fluency factors. It may aid us in determining what fluency factors are most important for inclusion in a stuttering treatment program. In addition, it may provide some valuable information regarding your individual needs and abilities, particularly during the maintenance period.

In order to further investigate these factors, we have recently added some assessment procedures to our standard testing. These procedures are optional and will be conducted at the Noble Building. Because the evaluation measures a wide variety of functions, it necessarily takes a significant period of time, up to several hours. Thus, these tests may be completed in one session or may be completed in three or four separate sessions. [Note: Due to the nature of the study, the first set of procedures must be completed before the third day of therapy.]

The first set of procedures consists of a series of activities which require you to respond verbally and manually. The administration time for this portion of the testing will vary from *two to three hours*. In the second procedure . you will be required to work independently on a computer for approximately *one and one half hours*.

If you should agree to participate in the study, it is understood that you may withdraw from the study at any time. Withdrawing from the study will not jeapardize your relationship with the Institute. To ensure confidentiality, you will only be identified in my master files by initials, age, and clinic date.

If you have any questions or concerns please feel free to call me. The telephone number at the Institute is 432-2619 and my home number is 436-0126. I would welcome any communication with you.

Thank you for your consideration and interest.

ATTENTION

The enclosed form is vital to the research project described in the attached letter. Please fill out the form and return it to the Institute as soon as possible. The address is as follows:

Laura Manz
Institute for Stuttering Treatment and Research
400, 8540 - 109 Street
Edmonton, Alberta

I hope you will be willing to help out in this project.

Thank you.

- -

I, __________ would like / not like to participate in this project.
(name - printed) (circle one)

If I agree to participate, I would prefer to be tested:

__ Prior to the commencement of therapy on the weekend of Oct. 10th - 11th

__ Prior to the commencement of therapy on the holiday Monday, Oct. 12th

__ In the evening following therapy on Oct. 13th

__ In the evening following therapy on Oct. 14th

__ In the evening following therapy on Oct. 15th

__ During lunch breaks of Oct. 13th, 14th and 15th

__ During the second day of the clinic (Oct. 14th)

__ During the third day of the clinic (Oct. 15th).

APPENDIX C

TIMING GUIDELINES (Adapted from Kully, 1988)

1. Activate the clock as soon as the speaker attempts to talk, even if there is a lengthy pause due to difficulty initiating speech.

2. Leave the clock on during any struggle behavior, even if it is inaudible.

3. Turn off the clock for any meditative or formulative pause greater than two seconds (count mentally - one thousand one, one thousand two). However, turn off the clock immediately if you are certain the speaker has finished or if he is interrupted by another speaker.

4. Do not activate the clock during production of syllables that constitute an isolated, fluent, automatic, responsive utterance. eg. 'Okay', 'yes', 'I see', 'bye'

GUIDELINES FOR COUNTING SYLLABLES (Adapted from Kully, 1988)

1. Count each syllable only once, regardless of how many times it is repeated.

   Exceptions:

   A. Part word repetitions are counted only once except when the repetition occurs because of mispronunciation.

   B. Syllables involved in word or phrase repetitions are counted only once except in cases of:
      - mispronunciations
      - revisions (changes which add or modify meaning or correct grammatical errors)
      - 'new' stuttering (stuttering which occurs on syllables which were originally fluent)

2. Count each syllable as either stuttered or fluent (see Guidelines for Counting Stutters)

3. Listen carefully to the speaker's pronunciation of multisyllabic words. Pronunciation of many words is variable between and within speakers.

4. Do not count as syllables any isolated, fluent, automatic, responsive utterances. eg. 'Okay', 'yes', 'I see', 'bye'

5. Do not count as syllables any fluent interjections (words extraneous to meaningful speech).
   - Examples are sounds and words such as 'um', 'like', 'well', 'you know' used as starters and fillers. Stutterers may use other less common words as well, eg. 'actually', 'indeed'.

GUIDELINES FOR COUNTING STUTTERS (Adapted from Kully, 1988)

1. Count each stuttered syllable only once regardless of the nature or number of struggle behaviors associated with its production.

2. Count all occurrences of part-word (sound or syllable) repetitions as stuttering moments unless the repetition is due to mispronunciation.

3. Count monosyllabic word repetitions as stuttered if:
   - the repetition is associated with visible or audible signs of tension
   - the repetition is characterized by a rapid tempo
   - the repetition occurred during a reading sample and there was no evidence of a reading error

   Do not count monosyllabic word repetitions as stuttered if:
   - the repetition was due to mispronunciation
   - the repetition was due to linguistic formation
   - the word was repeated in an attempt to get a 'running start' into the next word

4. Count multisyllabic (word or phrase) repetitions as stuttered if:
   - the repetition is associated with visible or audible signs of tension
   - the repetition is characterized by a rapid tempo
   - the repetition occurred during a reading sample and there was no

evidence of a reading error

Do not count multisyllabic word repetitions as stuttered if:
- the repetition was due to mispronunciation
- the repetition was due to linguistic formation
- the word/phrase was repeated in an attempt to get a 'running start' into the following word

5. Count a stutter on the first syllable that follows a starter repetition if:
   - the speaker shows signs of tension, then repeats the word or phrase OR the speaker begins to form a word, then experiences tension, and then 'backs up' and repeats the preceding word or phrase
   - the repetition 'doesn't work' and the speaker stutters on the word which follows the starter
   - the word or phrase is repeated two or more times with an absence of features that would identify the event as a stuttered event

6. Count one stutter on the syllable which contains the prolonged element, in the case of an audible prolongation.

7. Count one stutter on the syllable which immediately follows the period of silence, in the case of a silent prolongation.

   These behaviors can be distinguished from normal hesitations by one or more of the following features:
   - visual cues such as exaggerated or distorted facial movements
   - auditory cues such as slightly exploded or abrupt release when the silence is eventually broken
   - inappropriate locus of occurence, such as within a word or before a familiar word

8. Count a stutter on the word which follows the interjection if:
   - the speaker shows signs of tension OR begins to form a word, experiences tension, then interjects a sound or word before attempting to continue
   - the same interjection is repeated more than once
   - more than two different interjections are produced in succession
   - the speaker interjects a word or phrase which does not fit the context of the utterance

APPENDIX D

ERICKSON COMMUNICATION INVENTORY (S-24)
(Erickson, 1969; Andrews & Cutler, 1974)

Name: ____________________ Date: ____________________

Directions: Answer the following by circling "T" if a statement is generally true for you, or circle "F" if the statement is generally false for you. If the situation if unfamiliar or rare, jugde it on an "If it was familiar . . ." basis.

T F 1. I usually feel that I am making a favourable impression when I talk.

T F 2. I find it easy to talk with almost anyone.

T F 3. I find it very easy to look at my audience while speaking to a group.

T F 4. A person who is my teacher or my boss is hard to talk to.

T F 5. Even the idea of giving a talk in public makes me afraid.

T F 6. Some words are harder than others for me to say.

T F 7. I forget all about myself shortly after I begin to give a speech.

T F 8. I am a good mixer.

T F 9. People sometimes seem uncomfortable when I am talking to them.

T F 10. I dislike introducing one person to another.

T F 11. I often ask questions in group discussion.

T F 12. I find it easy to keep control of my voice when speaking.

T F 13. I do not mind speaking before a group.

T F 14. I do not talk well enough to do the kind of work I'd really like to do.

T F 15. My speaking voice is rather pleasant and easy to listen to.

T F 16. I am sometimes embarrassed by the way I talk.

T F 17. I face most speaking situations with complete confidence.

T F 18. There are few people I can talk with easily.

T F 19. I talk better than I write.

T F 20. I often feel nervous while talking.

T F 21. I find it hard to make talk when I meet new people.

T F 22. I feel pretty confident about my speaking ability.

T F 23. I wish that I could say things as clearly as others do.

T F 24. Even though I knew the right answer I have often failed to give it because I was afraid to speak.

APPENDIX E

SPEECH NATURALNESS RATING INSTRUCTIONS

(Martin, Haroldson & Triden, 1984)

We are studying what makes speech sound natural or unnatural. You will hear a number of 15 second speech samples. The samples will be separated by a few seconds of silence. Each sample will be introduced by a sample number which you should indicate beside the scale.

Your task is to rate the naturalness of each speech sample. If the speech sample sounds highly natural to you, circle the 1 on the scale. If the speech sample sounds highly unnatural, circle the 9 on the scale. If the speech sample sounds somewhere between highly natural and highly unnatural, circle the appropriate number on the scale. Do not hesitate to use the ends of the scale (1 or 9) when appropriate. "Naturalness" will not be defined for you. Make your rating of how natural or unnatural the speech samples sound to you.

SPEECH NATURALNESS RECORDING FORM

Name of rater: ____________________ Date: ____________________

SAMPLE HIGHLY NATURAL HIGHLY UNNATURAL

1. 1----2----3----4----5----6----7----8----9
2. 1----2----3----4----5----6----7----8----9
3. 1----2----3----4----5----6----7----8----9
4. 1----2----3----4----5----6----7----8----9
5. 1----2----3----4----5----6----7----8----9
6. 1----2----3----4----5----6----7----8----9
7. 1----2----3----4----5----6----7----8----9
8. 1----2----3----4----5----6----7----8----9
9. 1----2----3----4----5----6----7----8----9
10. 1----2----3----4----5----6----7----8----9
11. 1----2----3----4----5----6----7----8----9
12. 1----2----3----4----5----6----7----8----9
13. 1----2----3----4----5----6----7----8----9
14. 1----2----3----4----5----6----7----8----9
15. 1----2----3----4----5----6----7----8----9
16. 1----2----3----4----5----6----7----8----9
17. 1----2----3----4----5----6----7----8----9

APPENDIX F

ANNETT'S HANDEDNESS QUESTIONNAIRE
(Annett, 1967)

Which hand do you use:

1. To write a letter legibly?
2. To throw a ball to hit a target?
3. To hold a racket in tennis, squash, or badminton?
4. To hold a match whilst striking it?
5. To cut with scissors?
6. To guide a thread through the eye of a needle?
7. At the top of a broom while sweeping?
8. At the top of a shovel while moving sand or snow?
9. To deal playing cards?
10. To hammer a nail into wood?
11. To hold a toothbrush while cleaning your teeth?
12. To unscrew the lid of a jar?

Have you always been right/left handed?

APPENDIX G

RESEARCH CONSENT FORM
(Department of Speech Pathology and Audiology)

Topic of Project: Assessment of fluency factors.
Principal Researcher: L.A. Manz

Name ________________________ Date __________________

As a volunteer in this project,

a. I will be expected to take part in a testing session that will take approximately half a day to complete. This will be held at the Institute for Stuttering Treatment and Research and will take place prior to commencement of the intensive stuttering course.

b. The test sessions will be comprised of the following procedures:

  i) I will be asked to perform a number of simple motor skills tasks including tapping a telegraph key with my finger, squeezing a handle, following a path with a pencil, and placing pegs and forms in a board.

  ii) I will be asked to engage in some thinking tasks (e.g. thinking of words, detecting a pattern, matching symbols to number).

  iii) I will be asked some questions which are related to my health, lifestyle, personal experiences in speaking and social situations, and how I feel at the time of testing.

c. All testing procedures are noninvasive and involve no pain or discomfort.

I understand that information from the regular clinical procedures will be included as part of this project.

I am free to withdraw this consent and to discontinue participation at any time. My agreement or refusal to participate in the study will in no way affect my treatment at the Institute for Stuttering Treatment and Research.

My privacy will be protected in the following manner:

a. All research data obtained about me during the course of this study will be kept confidential and accessible only to the principal investigator. Identifiable data will not be released to any other persons without my written consent.

b. When the results are published, my identity will not be released.

I understand the terms of my participation in these procedures, including the procedures to be used and the inconveniences involved, and I agree to participate as a volunteer.

Signature of volunteer or guardian: ______________________

Date: ________________ Witness: ______________________

APPENDIX H

RELEASE OF INFORMATION
(Institute for Stuttering Treatment and Research)
Affiliated with the University of Alberta

This is to authorize the Institute for Stuttering Treatment and Research to obtain pertinent information on _______________. This information will remain confidential.

I also approve the release of information from the Institute to speech pathologists, physicians, and other health professionals.

Signed : _________________________ Date : _______________
(Parent or guardian if client under 18)

Witness : ________________________

APPENDIX I

AUTHORIZATION FOR PHOTOGRAPHY AND RECORDING
(Institute for Stuttering Treatment and Research)
Affiliated with the University of Alberta

In the interest of research and education, the Institute for Stuttering Treatment and Research is hereby authorized to take or cause to be taken still photographs, moving pictures, television and sound recordings of ______________________ and to use these phototgraphs and recordings for scientific purposes including the presentation and publication of scientific and professional reports.

I hereby expresssly waive any and all claims against the Institute for Stuttering Treatment and Research in any manner whatsoever relating to the said photographs and recordings.

Signed : ________________________ Date : ______________
(Parent or guardian if client under 18)

Witness : ________________________

AUTHORIZATION FOR USE OF RECORDINGS IN PUBLIC MEDIA
(Institute for Stuttering Treatment and Research)
Affiliated with the University of Alberta

I hereby authorize the Institute for Stuttering Treatment and Research to use photographs and audio or visual recordings of ______________________ in order to make known the work of the Institute to the general public. I expressly waive any and all claims against the Institute in any manner whatsoever relating to the said photographs and recordings.

Signed : ________________________ Date : ______________
(Parent or guardian if client under 18)

Witness : ________________________

APPENDIX J

RAW THESIS DATA

	%SS2	SPM2	S242	NAT2	DYP	DYNP	DY	FTP	FTNP
1	.26	175.90	5	2.33	55.25	45.50	9.75	48.80	50.20
2	.12	196.24	4	1.00	50.00	43.00	7.00	43.00	43.80
3	5.92	62.84	20	6.67	49.75	51.75	-2.00	49.00	50.40
4	0	187.06	15	3.00	46.65	40.90	5.75	53.40	44.40
5	.50	171.04	8	2.00	46.50	32.75	13.75	50.40	41.00
6	0	194.68	5	1.00	50.50	47.00	3.50	62.40	51.20
7	5.07	121.65	16	8.00	64.25	55.00	9.25	46.60	42.20
8	.37	198.99	13	1.33	34.25	34.25	0	52.40	39.60
9	.33	201.75	6	1.00	51.00	56.25	-5.25	50.00	50.60
10	2.51	180.05	3	4.33	39.25	33.50	5.75	35.40	28.80
11	0	172.83	4	3.67	46.00	38.50	7.50	51.20	47.20
12	.48	187.66	14	2.33	41.00	42.00	-1.00	42.00	34.40
13	1.54	82.74	14	1.67	37.75	35.50	2.25	52.20	49.20
14	1.32	163.69	•	3.00	15.25	14.00	1.25	41.00	36.00
15	0	141.42	10	7.33	52.75	45.50	7.25	47.00	43.20
16	.49	191.81	9	1.00	38.75	35.50	3.25	43.20	43.40
17	.29	119.71	•	4.00	14.50	15.00	.50	32.60	39.00

	FT	PPP	PPNP	PPB	PPA	PP	TR A	TR B	TPP	TPNP
1	-1.40	17	18	13	39	- 1	12.00	56.30	227.80	248.80
2	-.80	12	14	10	39	- 2	39.49	60.14	292.80	182.70
3	1.40	12	13	9	34	- 1	16.00	45.90	744.40	684.90
4	9.00	16	16	14	39	0	18.00	70.00	356.00	432.00
5	9.40	17	14	12	38	3	23.30	47.37	546.80	308.10
6	11.20	17	13	13	44	4	17.50	35.80	153.00	120.40
7	4.40	17	15	12	39	2	27.50	98.90	344.00	270.70
8	12.80	14	12	11	38	2	8.12	21.30	190.00	175.90
9	-.60	16	16	13	37	0	14.00	30.60	247.90	203.70
10	6.60	11	13	10	29	- 2	43.00	156.00	290.00	211.00
11	4.00	14	14	13	39	0	19.00	56.00	446.00	489.00
12	7.60	13	11	8	29	2	27.00	54.00	314.00	184.00
13	11.45	12	12	10	31	0	44.20	147.90	567.10	581.10
14	20.75	13	13	12	26	0	19.50	50.50	289.80	331.20
15	-9.55	14	13	10	34	1	24.00	57.00	428.00	215.00
16	4.65	17	17	12	39	0	28.36	56.71	265.90	369.80
17	24.50	14	12	14	27	2	16.26	41.80	254.00	218.80

	TPB	TPM	TPL	TP	HCT	WISC	SG	SDO	SDW	SD
1	125.20	10	7	-21.00	24	6	.524	61	47	14
2	281.30	1	6	110.10	17	12	-.065	60	87	-27
3	709.30	0	0	59.50	48	10	.403	18	50	-32
4	187.00	9	5	-76.00	25	2	.533	59	61	-2
5	135.60	9	7	238.70	24	8	-.124	73	50	23
6	97.70	8	5	32.60	19	4	.826	54	53	1
7	143.70	9	4	73.70	59	11	.229	50	44	6
8	63.90	5	3	14.10	19	16	.467	57	49	8
9	59.60	10	8	44.20	18	4	.256	73	92	-19
10	184.00	3	2	79.00	111	45	.190	59	51	8
11	159.00	7	4	-43.00	38	18	1.017	54	53	1
12	160.00	9	5	130.00	72	49	.274	44	57	-13
13	459.10	6	2	-14.00	133	46	.129	37	44	-7
14	90.10	6	4	-41.40	40	26	.354	50	52	-2
15	207.00	8	4	213.00	36	61	.480	57	58	-1
16	218.10	8	5	-103.90	73	28	.192	53	57	-4
17	101.70	4	4	35.20	23	47	.451	36	33	3

	OWF	WWF	WF	VIQ	PIQ	FSIQ	IQ	%SS1	SPM1	S241
1	17.67	16.33	1.34	127	136	133	-9	19.31	121.84	21
2	12.33	10.67	1.66	111	103	107	8	2.33	172.89	21
3	5.67	8.00	-2.33	98	89	93	9	53.96	24.45	20
4	10.67	8.67	2.00	127	122	128	5	7.21	127.06	•
5	15.67	8.00	7.67	79	101	86	-22	8.56	143.45	9
6	15.67	15.67	0	132	130	133	2	2.14	216.48	15
7	15.67	15.00	.67	102	96	99	6	10.75	100.78	22
8	14.00	10.20	3.80	118	104	112	14	27.99	89.81	23
9	11.67	9.67	2.00	123	136	131	-13	2.05	191.42	18
10	21.00	13.00	7.00	83	85	83	-2	6.72	173.72	20
11	19.00	18.33	.67	122	110	117	12	0	182.86	7
12	9.00	8.00	1.00	96	91	92	5	10.53	125.61	10
13	7.00	10.67	-3.67	98	86	92	12	31.80	86.67	20
14	11.40	10.40	1.00	124	133	133	-9	15.61	148.39	•
15	10.00	8.33	1.67	107	116	111	-9	11.57	152.17	14
16	11.00	8.00	3.00	99	105	102	-6	22.26	118.33	21
17	7.00	4.60	2.40	123	138	134	-15	5.50	121.24	•

	NAT1	AGE	EDUC	FAM HIST	HAND
1	1.67	37	18	POSITIVE	RIGHT
2	4.00	16	11	POSITIVE	RIGHT
3	4.33	30	10	NEGATIVE	RIGHT
4	3.67	35	21	POSITIVE	RIGHT
5	3.67	20	9	NEGATIVE	RIGHT
6	1.67	40	17	NEGATIVE	RIGHT
7	5.33	29	17	POSITIVE	RIGHT
8	4.00	13	7	POSITIVE	RIGHT
9	1.67	22	15	POSITIVE	LEFT
10	3.67	22	12	POSITIVE	RIGHT
11	2.67	41	18	NEGATIVE	RIGHT
12	1.67	26	14	NEGATIVE	RIGHT
13	4.33	42	11	•	LEFT
14	4.00	10	5	POSITIVE	RIGHT
15	3.00	17	11	POSITIVE	RIGHT
16	1.67	15	10	NEGATIVE	RIGHT
17	7.00	9	4	NEGATIVE	LEFT

APPENDIX K

NEUROPSYCHOLOGICAL PROFILES OF OUTLIERS

SUBJECT #3

	STANDARD DEVIATIONS												
	IMPAIRED						NORMAL				ABOVE NORMAL		
	-3		-2		-1		0		1		2		3
VERBAL ABILITIES													
ORAL WORD FLUENCY	X												
WRITTEN WORD FLUENCY			X										
PERCEPTUAL-MOTOR ABILITIES I													
TRAIL MAKING A									X				
TRAIL MAKING B								X					
SYMBOL GESTALT							X						
SYMBOL-DIGIT: WRITTEN				X									
SYMBOL-DIGIT: ORAL	X												
PERCEPTUAL-MOTOR ABILITIES II													
PURDUE PEGBOARD: RIGHT		X											
TACTUAL PERF: RIGHT	X												
PURDUE PEGBOARD: LEFT				X									
TACTUAL PERF: LEFT	X												
PURDUE PEGBOARD: BOTH		X											
PURDUE PEGBOARD: ASSEMBLIES				X									
TACTUAL PERF: BOTH	X												
ABSTRACT ABILITIES													
CATEGORY TEST				X									
WISCONSIN CARD SORTING							X						
LEARNING/MEMORY													
TACTUAL PERF: MEMORY	X												
TACTUAL PERF: LOCALIZATION		X											
MOTOR FUNCTIONS													
DYNAMOMETER: RIGHT							X						
FINGER TAPPING: RIGHT							X						
DYNAMOMETER: LEFT								X					
FINGER TAPPING: LEFT								X					
MAB													
VERBAL IQ							X						
PERFORMANCE IQ					X								
FULL SCALE IQ						X							

SUBJECT #10

	STANDARD DEVIATIONS												
	IMPAIRED						NORMAL				ABOVE NORMAL		
	-3		-2		-1		0		1		2		3
VERBAL ABILITIES													
ORAL WORD FLUENCY										X			
WRITTEN WORD FLUENCY							X						
PERCEPTUAL-MOTOR ABILITIES I													
TRAIL MAKING A		X											
TRAIL MAKING B	X												
SYMBOL GESTALT					X								
SYMBOL-DIGIT: WRITTEN					X								
SYMBOL-DIGIT: ORAL				X									
PERCEPTUAL-MOTOR ABILITIES II													
PURDUE PEGBOARD: RIGHT		X											
TACTUAL PERF: RIGHT							X						
PURDUE PEGBOARD: LEFT					X								
TACTUAL PERF: LEFT							X						
PURDUE PEGBOARD: BOTH			X										
PURDUE PEGBOARD: ASSEMBLIES				X									
TACTUAL PERF: BOTH						X							
ABSTRACT ABILITIES													
CATEGORY TEST	X												
WISCONSIN CARD SORTING		X											
LEARNING/MEMORY													
TACTUAL PERF: MEMORY	X												
TACTUAL PERF: LOCALIZATION				X									
MOTOR FUNCTIONS													
DYNAMOMETER: RIGHT					X								
FINGER TAPPING: RIGHT			X										
DYNAMOMETER: LEFT				X									
FINGER TAPPING: LEFT		X											
MAB													
VERBAL IQ					X								
PERFORMANCE IQ					X								
FULL SCALE IQ					X								

SUBJECT #13

	STANDARD DEVIATIONS												
	IMPAIRED				NORMAL					ABOVE NORMAL			
	-3		-2		-1		0		1		2		3
VERBAL ABILITIES													
ORAL WORD FLUENCY		X											
WRITTEN WORD FLUENCY					X								
PERCEPTUAL-MOTOR ABILITIES I													
TRAIL MAKING A		X											
TRAIL MAKING B	X												
SYMBOL GESTALT				X									
SYMBOL-DIGIT: WRITTEN				X									
SYMBOL-DIGIT: ORAL	X												
PERCEPTUAL-MOTOR ABILITIES II													
PURDUE PEGBOARD: RIGHT			X										
TACTUAL PERF: RIGHT	X												
PURDUE PEGBOARD: LEFT			X										
TACTUAL PERF: LEFT	X												
PURDUE PEGBOARD: BOTH			X										
PURDUE PEGBOARD: ASSEMBLIES			X										
TACTUAL PERF: BOTH	X												
ABSTRACT ABILITIES													
CATEGORY TEST	X												
WISCONSIN CARD SORTING				X									
LEARNING/MEMORY													
TACTUAL PERF: MEMORY				X									
TACTUAL PERF: LOCALIZATION				X									
MOTOR FUNCTIONS													
DYNAMOMETER: RIGHT				X									
FINGER TAPPING: RIGHT								X					
DYNAMOMETER: LEFT				X									
FINGER TAPPING: LEFT					X								
MAB													
VERBAL IQ							X						
PERFORMANCE IQ					X								
FULL SCALE IQ						X							